# PCTEST ENGINEERING LABORATORY, INC.

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# HEARING AID COMPATIBILITY CERTIFICATE

**Applicant Name:**
Nokia Inc.
12278 Scripps Summit Drive
San Diego, CA 92131-3697
United States

**Date of Testing:**
Nov. 25 - Dec. 5, 2005
**Test Site/Location:**
PCTEST Lab, Columbia, MD, USA
**Test Report Serial No.:**
HAC.0511220817.QMN

| | |
|---|---|
| **FCC ID:** | **QMNRM-124** |
| **APPLICANT:** | **NOKIA INC.** |

| | |
|---|---|
| **Application Type:** | Certification |
| **FCC Rule Part(s):** | § 20.19(b), §6.3(v), §7.3(v) |
| **HAC Standard:** | ANSI PC63.19-2005 D3.6 |
| **FCC Classification:** | Licensed Transmitter Held to Ear (PCE) |
| **EUT Type:** | Tri-Mode Dual-Band Phone |
| **Model(s):** | 2855i |
| **Tx Frequency:** | 824.04 - 848.97 MHz (AMPS)<br>824.70 - 848.31 MHz (CDMA)<br>1851.25 - 1908.75 MHz (PCS) |
| **Test Device Serial No.:** | *Pre-Production Sample* [S/N: 215B9372] |

| | |
|---|---|
| **PC63.19 HAC Rated Category:** | **M3 (RF EMISSIONS)** |

This wireless portable device has been shown to be hearing-aid compatible under the above rated category, specified in ANSI/IEEE Std. PC63.19 and had been tested in accordance with the specified measurement procedures. Hearing-Aid Compatibility is based on the assumption that all production units will be designed electrically identical to the device tested in this report.

I attest to the accuracy of data. All measurements reported herein were performed by me or were made under my supervision and are correct to the best of my knowledge and belief. I assume full responsibility for the completeness of these measurements and vouch for the qualifications of all persons taking them.

*PCTEST certifies that no party to this application has been denied the FCC benefits pursuant to Section 5301 of the Anti-Drug Abuse Act of 1988, 21 U.S.C. 862.*

Randy Ortanez
President

# T A B L E   O F   C O N T E N T S

# 1. INTRODUCTION

On July 10, 2003, the Federal Communications Commission (FCC) adopted new rules requiring wireless manufacturers and service providers to provide digital wireless phones that are compatible with hearing aids. The FCC has modified the exemption for wireless phones under the Hearing Aid Compatibility Act of 1998 (HAC Act) in WT Docket 01-309 RM-8658[1] to extend the benefits of wireless telecommunications to individuals with hearing disabilities. These benefits encompass business, social and emergency communications, which increase the value of the wireless network for everyone. An estimated more than 10% of the population in the United States show signs of hearing impairment and of that fraction, almost 80% use hearing aids. Approximately 500 million people worldwide suffer from hearing loss.

**Compatibility Tests Involved:**

The standard calls for wireless communications devices to be measured for:

- RF Electric-field emissions
- RF Magnetic-field emissions
- T-coil mode, magnetic-signal strength in the audio band
- T-coil mode, magnetic-signal frequency response through the audio band
- T-coil mode, magnetic-signal and noise articulation index

The hearing aid must be measured for:

- RF immunity in microphone mode
- RF immunity in T-coil mode

In the following tests and results, this report includes the evaluation for a wireless communications device.

**Figure 1 Hearing Aid *in-vitu***

[1] FCC Rule & Order, WT Docket 01-309 RM-8658

# 2. TEST SITE LOCATION

## 2.1 INTRODUCTION

The map at the right shows the location of the PCTEST LABORATORY in Columbia, Maryland. It is in proximity to the FCC Laboratory, the Baltimore-Washington International (BWI) airport, the city of Baltimore and Washington, DC (See Figure 2).

These measurement tests were conducted at the PCTEST Engineering Laboratory, Inc. facility in New Concept Business Park, Guilford Industrial Park, Columbia, Maryland. The site address is 6660-B Dobbin Road, Columbia, MD 21045. The test site is one of the highest points in the Columbia area with an elevation of 390 feet above mean sea level. The site coordinates are 39° 11’15” N latitude and 76° 49’ 38” W longitude. The facility is 1.5 miles North of the FCC laboratory, and the ambient signal and ambient signal strength are approximately equal to those of the FCC laboratory. There are no FM or TV transmitters within 15 miles of the site. The detailed description of the measurement facility was found to be in compliance with the requirements of § 2.948 according to ANSI C63.4 on October 19, 2002.

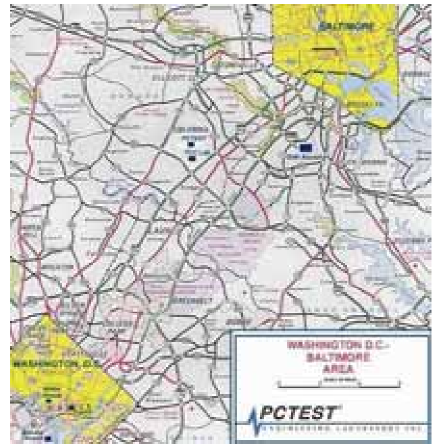



**Figure 2**
Map of the Greater Baltimore and Metropolitan Washington, D.C. area

## 2.2 Test Facility / NVLAP Accreditation:

Measurements were performed at an independent accredited PCTEST Engineering Lab located in Columbia, MD 21045, U.S.A.


- PCTEST facility is an FCC registered (PCTEST Reg. No. 90864) test facility with the site description report on file and has met all the requirements specified in Section 2.948 of the FCC Rules and Industry Canada (IC 2451).
- PCTEST Lab is accredited to ISO 17025 by U.S. National Institute of Standards and Technology (NIST) under the National Voluntary Laboratory Accreditation Program (NVLAP Lab code: 100431-0) in EMC, FCC and Telecommunications.
- PCTEST Lab is accredited to ISO 17025 by the American Association for Laboratory Accreditation (A2LA) in Specific Absorption Rate (SAR) testing, CTIA Test Plans, and wireless testing for FCC, HAC, CTIA OTA and Industry Canada Rules.
- PCTEST Lab is a recognized U.S. Conformity Assessment Body (CAB) in EMC and R&TTE (n.b. 0982) under the U.S.-EU Mutual Recognition Agreement (MRA).
- PCTEST TCB is a Telecommunication Certification Body (TCB) accredited to ISO/IEC Guide 65 by the American National Standards Institute (ANSI) in all scopes of FCC Rules.
- PCTEST facility is an IC registered (IC-2451) test laboratory with the site description on file at Industry Canada.
- PCTEST is a CTIA Authorized Test Laboratory (CATL) in AMPS and CDMA mobile phones.

# 3. EUT DESCRIPTION

NOKIA

| | |
|---|---|
| FCC ID: | QMNRM-124 |
| Manufacturer: | Nokia Inc.<br>12278 Scripps Summit Drive<br>San Diego, CA 92131-3697<br>United States |
| Trade Name: | NOKIA |
| Model(s): | 2855i |
| Serial Number: | 215B9372 |
| Tx Frequencies: | 824.04 - 848.97 MHz (AMPS)<br>824.70 - 848.31 MHz (CDMA)<br>1851.25 - 1908.75 MHz (PCS) |
| Antenna Configurations: | Extendable Antenna |
| Maximum Conducted Power (EMC/SAR): | 25 dBm (CDMA), 23 dBm (PCS) |
| Maximum Conducted Power (HAC): | 25.1 dBm (CDMA), 23.2 dBm (PCS) |
| HAC Test Configurations: | CDMA, Antenna In, Channels 1013, 384, 777<br>CDMA, Antenna Out, Channels 1013, 384, 777<br>PCS, Antenna In, Channels 25, 600, 1175<br>PCS, Antenna Out, Channels 25, 600, 1175 |
| FCC Classification: | Licensed Transmitter Held to Ear (PCE) |
| EUT Type: | Tri-Mode Dual-Band Phone |

**Figure 3**
**Device Under Test**

# 4. ANSI/IEEE PC63.19 PERFORMANCE CATEGORIES

## I. RF EMISSIONS

The ANSI Standard presents performance requirements for acceptable interoperability of hearing aids with wireless communications devices. When these parameters are met, a hearing aid operates acceptably in close proximity to a wireless communications device.

| Category | Hearing aid RF Parameters | | Telephone RF Parameters | |
|---|---|---|---|---|
| Near field Category | E-field immunity CW dB(V/m) | H-field immunity CW dB(A/m) | E-field emissions CW dB(V/m) | H-field emissions CW dB(A/m) |
| M1 | 30.0 to 35.0 | –23.0 to –18.0 | 46 to 51 + 0.5 x AWF | –4.4 to 0.6 +0.5 x AWF |
| M2 | 35.0 to 40.0 | –18.0 to –13.0 | 41 to 46 + 0.5 x AWF | –9.4 to –4.4 +0.5 x AWF |
| M3 | 40.0 to 45.0 | –13.0 to –8.0 | 36 to 41 + 0.5 x AWF | –14.4 to –9.4 +0.5 x AWF |
| M4 | > 45.0 | > –8.0 | < 36 + 0.5 x AWF | < –14.4 + 0.5 x AWF |

Table 6.1
Hearing aid and WD near-field categories as defined in draft ANSI PC63.19. During testing, the hearing aid must maintain an input-referenced interference level of less than 55 dB and a gain compression of less than 6 dB.

## II. ARTICULATION WEIGHTING FACTOR (AWF)

| Standard | Technology | Articulation Weighing Factor (AWF) |
|---|---|---|
| T1/T1P1/3GPP | UMTS (WCDMA) | 0 |
| IS-95 | CDMA | 0 |
| iDEN™ | TDMA (22 and 11 Hz) | 0 |
| J-STD-007 | GSM (217 Hz) | -5 |

Table 6.2
AWF has been developed from information presented to the committee regarding the interference potential of the various modulation types according to ANSI PC63.19

## 5. SYSTEM SPECIFICATIONS

### ER3DV6 E-Field Probe Description

| | |
|---|---|
| Construction: | One dipole parallel, two dipoles normal to probe axis<br>Built-in shielding against static charges |
| Calibration: | In air from 100 MHz to 3.0 GHz<br>(absolute accuracy ±6.0%, k=2) |
| Frequency: | 100 MHz to > 6 GHz;<br>Linearity: ± 0.2 dB (100 MHz to 3 GHz) |
| Directivity | ± 0.2 dB in air (rotation around probe axis)<br>± 0.4 dB in air (rotation normal to probe axis) |
| Dynamic Range | 2 V/m to > 1000 V/m<br>(M3 or better device readings fall well below diode compression point) |
| Linearity: | ± 0.2 dB |
| Dimensions | Overall length: 330 mm (Tip: 16 mm)<br>Tip diameter: 8 mm (Body: 12 mm)<br>Distance from probe tip to dipole centers: 2.5 mm |

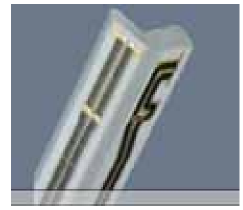


**Figure 4**
E-field Free-space Probe

### H3DV6 H-Field Probe Description

| | |
|---|---|
| Construction: | Three concentric loop sensors with 3.8 mm loop diameters<br>Resistively loaded detector diodes for linear response<br>Built-in shielding against static charges |
| Frequency: | 200 MHz to 3 GHz (absolute accuracy ± 6.0%, k=2);<br>Output linearized |
| Directivity: | ± 0.25 dB (spherical isotropy error) |
| Dynamic Range: | 10 mA/m to 2 A/m at 1 GHz<br>(M3 or better device readings fall well below diode compression point) |
| Dimensions: | Overall length: 330 mm (Tip: 40 mm)<br>Tip diameter: 6 mm (Body: 12 mm)<br>Distance from probe tip to dipole centers: 3 mm |
| E-Field Interference: | < 10% at 3 GHz (for plane wave) |

**Figure 5**
H-Field Free-space Probe

### Probe Tip Description

HAC field measurements take place in the close near field with high gradients. Increasing the measuring distance from the source will generally decrease the measured field values (in case of the validation dipole approx. 10% per mm).

Magnetic field sensors are measuring the integral of the H-field across their sensor area surrounded by the loop. They are calibrated in a precise, homogeneous field. When measuring a gradient field, the result will be very close to the field in the center of the loop which is equivalent to the value of a homogeneous field equivalent to the center value. But it will be different from the field at the border of the loop.

Consequently, two sensors with different loop diameters - both calibrated ideally - would give different results when measuring from the edge of the probe sensor elements. The behavior for electrically small E-field sensors is equivalent. See below for distance plots from a WD which show the conservative nature of field readings at the probe element center vs. measurements at the sensor end:

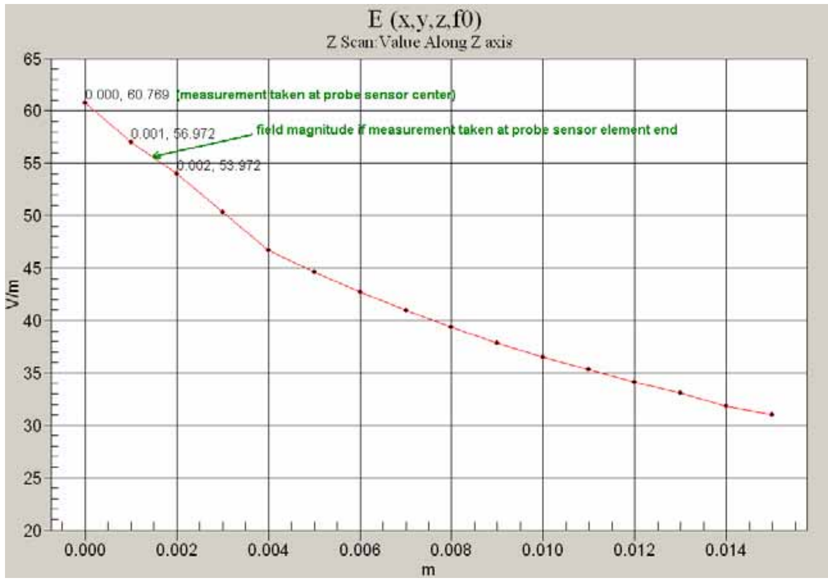



**Figure 6** Z-axis scan at maximum point above wireless device for E-field

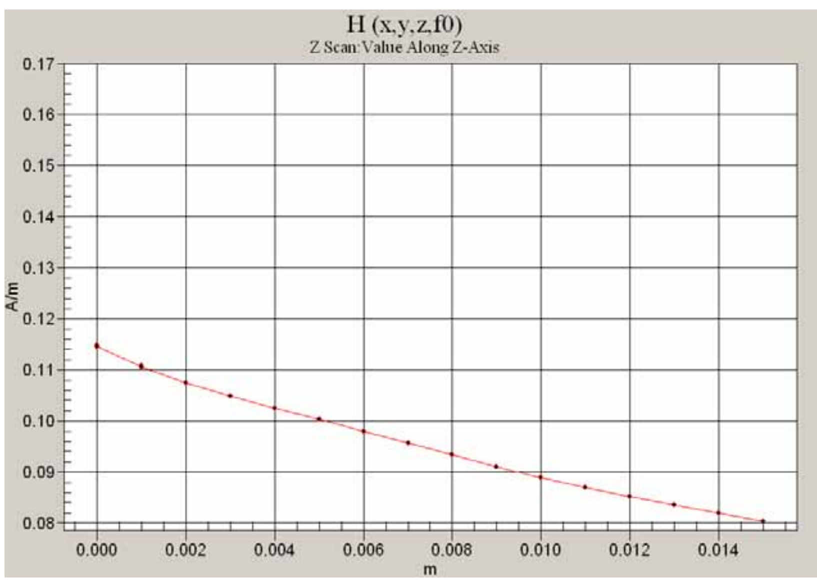



**Figure 7** Z-Axis Scan at maximum point above wireless device for H-field

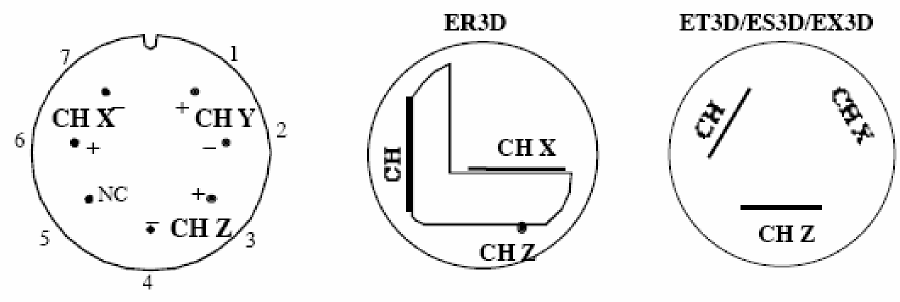
The magnetic field loops of the H3D probes are concentric, with the center 3mm from the tip for H3DV6. Their radius is 1.9mm.

The electric field probes have a more irregular internal geometry because it is physically not possible to have the 3 orthogonal sensors situated with the same center. The effect of the different sensor centers is accounted for in the HAC uncertainty budget ("sensor displacement"). Their geometric center is at 2.5mm from the tip, and the element ends are 1.1mm closer to the tip.



**Connector Plan**




(seen from back) (seen from front)

The antistatic shielding inside the probe is connected to the probe connector case.

It is recommended to connect the probes with the amplifier using a short and well shielded cable and to connect the cable shielding with the connector case.

### Instrumentation Chain

**Equation 1**

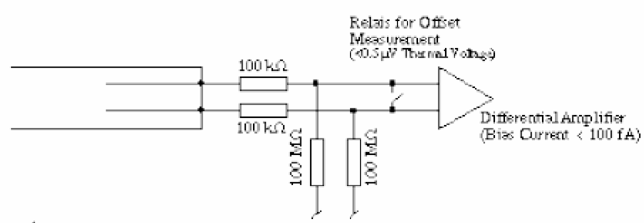
**Conversion of Connector Voltage $u_i$ to E-Field $E_i$**

$$E_i = \sqrt{\frac{u_i + (u_i^2 \cdot CF\ )/(\ DCP\ )}{Norm_i \quad \cdot ConvF}}$$

whereby

| | |
|---|---|
| $E_i$: | electric field in V/m |
| $u_i$: | voltage of channel i at the connector in µV |
| $Norm_i$: | sensitivity of channel i in $\mu V/(V/m)^2$ |
| *ConvF*: | enhancement factor in liquid (ConvF=1 for Air) |
| *DCP*: | diode compression point in µV |
| *CF*: | signal crest factor (peak power/average power) |

**Conditions of Calibration**




Please note:

- a lower input impedance of the amplifier will result in different sensitivity factors $Norm_i$ and *DCP*
- larger bias currents will cause higher offset

**Probe Response to Frequency**

The E-field sensors have inherently a very flat frequency response. They are calibrated with a number of frequencies resulting in a common calibration factor, with the frequency behavior documented in the calibration certificate (See also below).

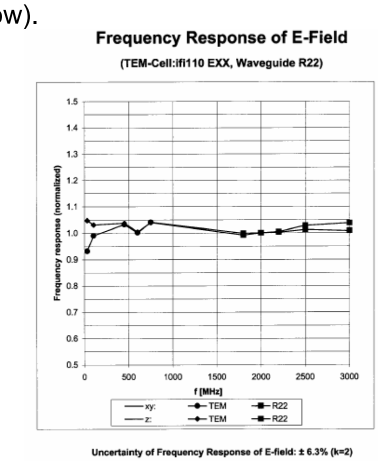



**Figure 8** E-Field Probe Frequency Response

H-field sensors have a frequency dependent sensitivity which is evaluated for a series of frequencies also visible in the probe calibration certificate. The calibration factors result from a fitting algorithm. The proper conversion is calculated by the DASY4 software depending on the frequency setting in the procedure. See below for H-field frequency response:

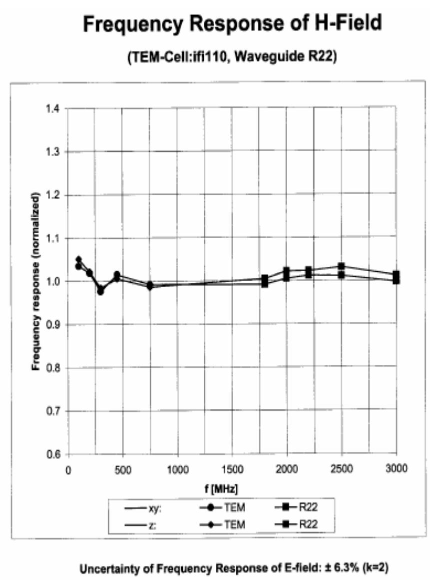



**Figure 9** H-Field Probe Frequency Response

## Conversion to Peak

Peak is defined as Peak Envelope Power. All raw measurements from the HAC measurement system are RMS values. The DASY4 system incorporates the crest factor of the signal in the computation of the RMS values (See Equation 1). Although the software also has capability to estimate the peak field by applying a square root of crest factor value to the readings, the probe modulation factor was applied manually instead per PC63.19 in the measurement tables in this report. The equation to convert the raw measurements in the data tables are:

$$\text{Peak Field} = 20 \cdot \log(\text{Raw} \cdot \text{PMF})$$

<u>Where:</u>

Peak Field = Peak field (in dBV/m or dBA/m)
Raw = Raw field measurement from the measurement system (in V/m or A/m).
PMF = Probe Modulation Factor (in linear units).

## SPEAG Robotic System

E-field and H-field measurements are performed using the DASY4 automated dosimetric assessment system. The DASY4 is made by Schmid & Partner Engineering AG (SPEAG) in Zurich, Switzerland and consists of high precision robotics system (Staubli), robot controller, Pentium 4 computer, near-field probe, probe alignment sensor, and the HAC phantom. The robot is a six-axis industrial robot performing precise movements to position the probe to the location (points) of maximum electromagnetic field (EMF).

**Figure 10**
SPEAG Robotic System

**Figure 11**
PCTEST Lab Acoustics Facility

## System Hardware

A cell controller system contains the power supply, robot controller, teach pendant (Joystick), and a remote control used to drive the robot motors. The PC consists of the Gateway Pentium 4 2.53 GHz computer with Windows XP system and RF Measurement Software DASY4 v4.5 (with HAC Extension), A/D interface card, monitor, mouse, and keyboard. The Staubli Robot is connected to the cell controller to allow software manipulation of the robot. A data acquisition electronic (DAE) circuit that performs the signal amplification, signal multiplexing, AD-conversion, offset measurements, mechanical surface detection, collision detection, etc. is connected to the Electro-optical coupler

(EOC). The EOC performs the conversion from the optical into digital electric signal of the DAE and transfers data to the PC plug-in card.

### System Electronics

The DAE consists of a highly sensitive electrometer-grade preamplifier with auto-zeroing, a channel and gain-switching multiplexer, a fast 16 bit AD-converter and a command decoder and control logic unit. Transmission to the PC-card is accomplished through an optical downlink for data and status information and an optical uplink for commands and clock lines. The mechanical probe mounting device includes two different sensor systems for frontal and sidewise probe contacts. They are also used for mechanical surface detection and probe collision detection. The robot uses its own controller with a built in VME-bus computer.

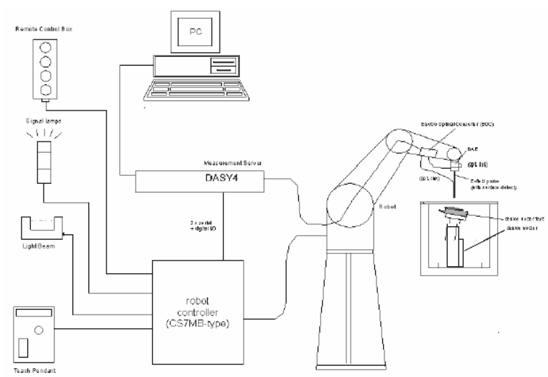



**Figure 12**
SPEAG Robotic System Diagram

### DASY4 Instrumentation Chain

The first step of the evaluation is a linearization of the filtered input signal to account for the compression characteristics of the detector diode. The compensation depends on the input signal, the diode type and the DC-transmission factor from the diode to the evaluation electronics. If the exciting field is pulsed, the crest factor of the signal must be known to correctly compensate for peak power. The formula for each channel can be given as:

$$V_i = U_i + U_i^2 \cdot \frac{cf}{dcp_i}$$

| | | | |
|---|---|---|---|
| with | $V_i$ | = compensated signal of channel i | (i = x, y, z) |
| | $U_i$ | = input signal of channel i | (i = x, y, z) |
| | $cf$ | = crest factor of exciting field | (DASY parameter) |
| | $dcp_i$ | = diode compression point | (DASY parameter) |

From the compensated input signals the primary field data for each channel can be evaluated:

$$\text{E} - \text{fieldprobes}: \qquad E_i = \sqrt{\frac{V_i}{Norm_i \cdot ConvF}}$$

$$\text{H} - \text{fieldprobes}: \qquad H_i = \sqrt{V_i} \cdot \frac{a_{i0} + a_{i1} f + a_{i2} f^2}{f}$$

with $V_i$ = compensated signal of channel i (i = x, y, z)
$Norm_i$ = sensor sensitivity of channel i (i = x, y, z)
$\mu V/(V/m)^2$ for E-field Probes
$ConvF$ = sensitivity enhancement in solution
$a_{ij}$ = sensor sensitivity factors for H-field probes
$f$ = carrier frequency [GHz]
$E_i$ = electric field strength of channel i in V/m
$H_i$ = magnetic field strength of channel i in A/m

The RSS value of the field components gives the total field strength (Hermitian magnitude):

$$E_{tot} = \sqrt{E_x^2 + E_y^2 + E_z^2}$$

The primary field data are used to calculate the derived field units.

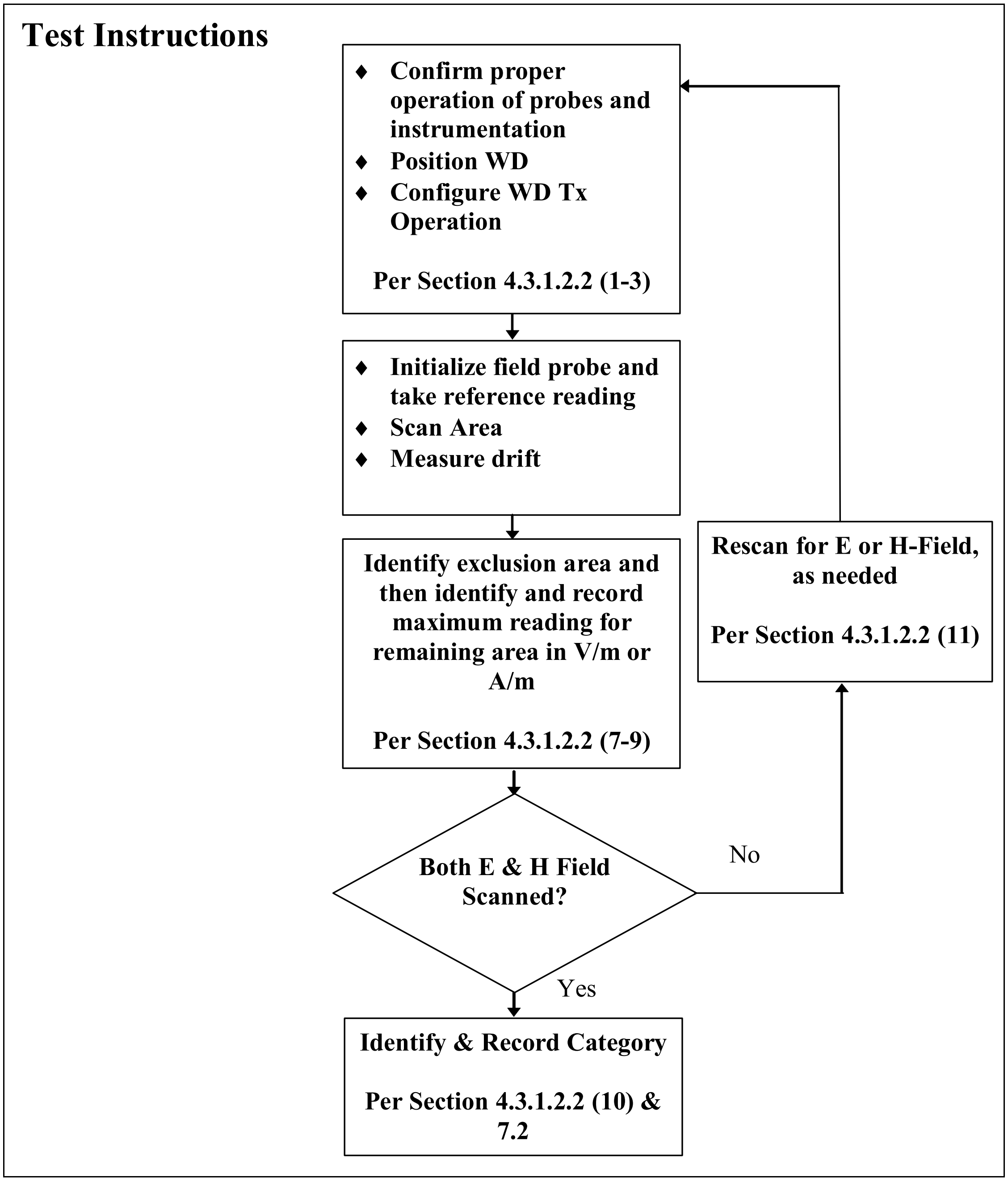
The measurement/integration time per point, as specified by the system manufacturer is >500 ms.

The signal response time is evaluated as the time required by the system to reach 90% of the expected final value after an on/off switch of the power source with an integration time of 500 ms and a probe response time of <5 ms. In the current implementation, DASY4 waits longer than 100 ms after having reached the grid point before starting a measurement, i.e., the response time uncertainty is negligible.

If the device under test does not emit a CW signal, the integration time applied to measure the electric field at a specific point may introduce additional uncertainties due to the discretization. The tolerances for the different systems had the worst-case of 2.6%.

# 6. TEST PROCEDURE

## I. RF EMISSIONS





**Test Setup**

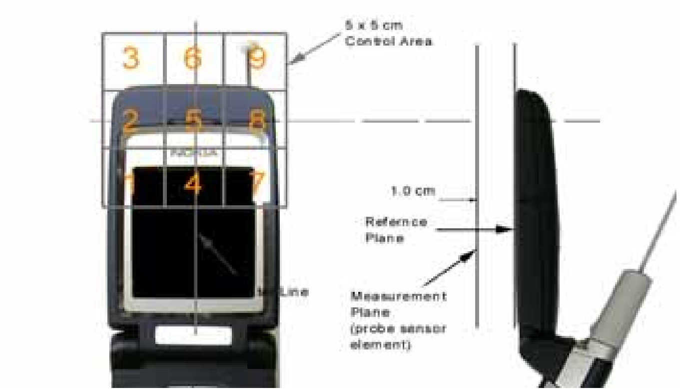



**Figure 13**
E/H-Field Emissions Test Setup Diagram

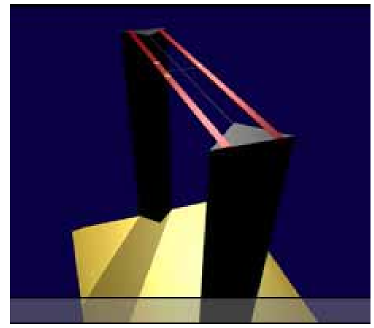


**Figure 14**
HAC Phantom

**RF Emissions Test Procedure:**

The following illustrate a typical RF emissions test scan over a wireless communications device:

1. Proper operation of the field probe, probe measurement system, other instrumentation, and the positioning system was confirmed.

2. WD is positioned in its intended test position, acoustic output point of the device perpendicular to the field probe.

3. The WD operation for maximum rated RF output power was configured and confirmed with the base station simulator, at the test channel and other normal operating parameters as intended for the test. The battery was ensured to be fully charged before each test.

4. The center sub-grid was centered over the center of the acoustic output (also audio band magnetic output, if applicable). The WD audio output was positioned tangent (as physically possible) to the measurement plane.

5. A surface calibration was performed before each setup change to ensure repeatable spacing and proper maintenance of the measurement plane using the HAC Phantom.

6. The measurement system measured the field strength at the reference location.

7. Measurements at 2mm increments in the 5 x 5 cm region were performed and recorded. A 360$^{o}$ rotation about the azimuth axis at the maximum interpolated position was measured. For the worst-case condition, the peak reading from this rotation was used in re-evaluating the HAC category.

8. The system performed a drift evaluation by measuring the field at the reference location.

9. Steps 1-8 were done for both the E and H-Field measurements.

# 7. SYSTEM CHECK

## I. System Check Parameters

The input signal was an un-modulated continuous wave. The following points were taken into consideration in performing this check:

- Average Input Power P = 100mW RMS (20dBm RMS) after adjustment for return loss
- The test fixture must meet the 2 wavelength separation criterion
- The proper measurement of the 1 cm probe to dipole separation, which is measured from top surface of the dipole to the calibration reference point of the sensor, defined by the probe manufacturer is shown in the following diagram:

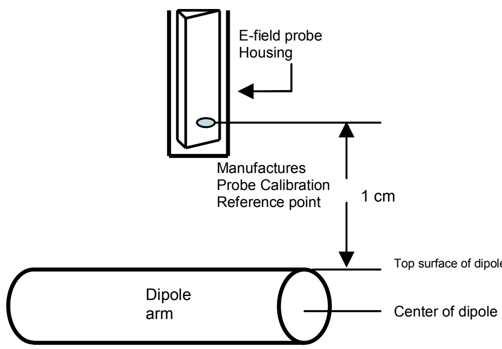



**Figure 15**
Separation Distance from Dipole to Field Probe

RF power was recorded using both an average reading meter and a peak reading meter. Readings of the probe are provided by the measurement system.

To assure proper operation of the near-field measurement probe the input power to the dipole shall be commensurate with the full rated output power of the wireless device (e.g. - for a cellular phone wireless device the average peak antenna input power will be on the order of 100mW (i.e. - 20dBm) RMS after adjustment for any mismatch.

## II. Validation Procedure

A dipole antenna meeting the requirements given in PC63.19 was placed in the position normally occupied by the WD.

The length of the dipole was scanned with both E-field and H-field probes and the maximum values for each were recorded.

### Measurement of CW

Using the near-field measurement system, scan the antenna over the radiating dipole and record the greatest field reading observed. Due to the nature of E-fields about free-space dipoles, the two E-field peaks measured over the dipole are averaged to compensate for non-parallelity of the setup (

see manufacturer method on dipole calibration certificates, page 2). Field strength measurements shall be made only when the probe is stationary.

RF power was recorded using both an average and a peak power reading meter.

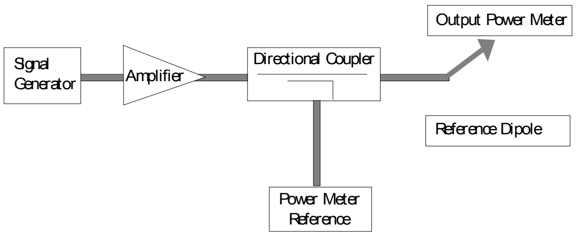



**Figure 16**
Setup for Desired Output Power to Dipole

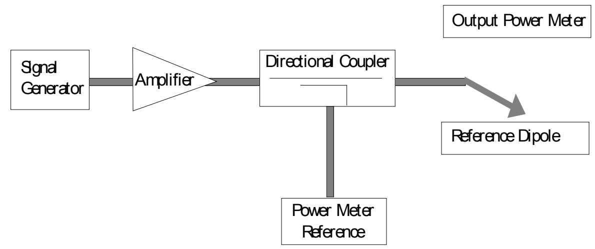



**Figure 17**
Setup to Dipole

Using this setup configuration, the signal generator was adjusted for the desired output power (100mW) at a specified frequency. The reference power from the coupled port of the directional coupler is recorded. Next, the output cable is connected to the reference dipole, as shown in Figure 17.

The input signal level was adjusted until the reference power from the coupled port of the directional coupler was the same as previously recorded, to compensate for the impedance mismatch between the output cable and the reference dipole. To assure proper operation of the near-field measurement probe the input power to the reference dipole was verified to the full rated output power of the wireless device. The dipole was secured in a holder in a manner to meet the 20 dB reflection. The near-field measurement probe was positioned over the dipole. The antenna was scanned over the appropriate sized area to cover the dipole from end to end. SPEAG uses 2D interpolation algorithms between the measured points. Please see below two dimensional plots showing that the interpolated values interpolate smoothly between 5mm steps for a free-space RF dipole:

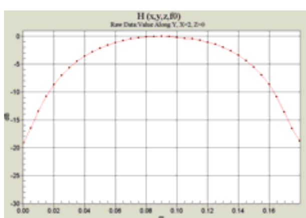


**Figure 18**
2-D Raw Data from scan along dipole axis

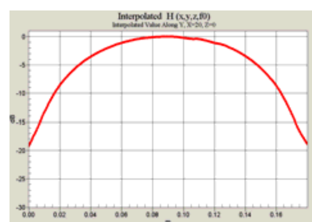


**Figure 19**
2-D Interpolated points from scan along dipole axis

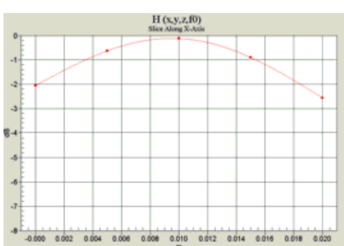


**Figure 20**
2-D Raw Data from scan along transverse axis

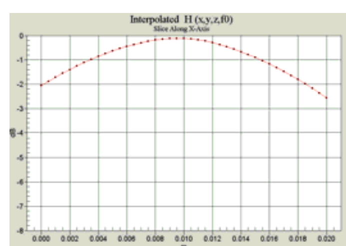


**Figure 21**
2-D Interpolated points from scan along transverse axis

## III. System Check Results

### Validation Results

| Frequency (MHz) | Input Power (dBm) | E-field Result (V/m) | Target Field (V/m) | % Deviation |
|---|---|---|---|---|
| 835 | 20.0 | 177.7 | **185.1** | **-4.0%** |
| 1880 | 20.0 | 143.6 | **145.8** | **-1.5%** |

| Frequency (MHz) | Input Power (dBm) | H-field Result (A/m) | Target Field (A/m) | % Deviation |
|---|---|---|---|---|
| 835 | 20.0 | 0.499 | **0.470** | **6.1%** |
| 1880 | 20.0 | 0.434 | **0.450** | **-3.7%** |

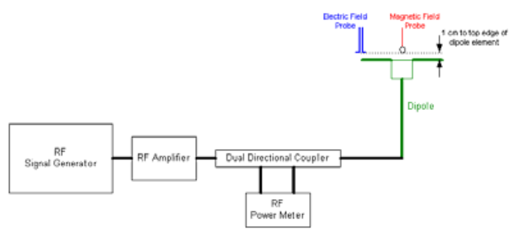



**Figure 22**
System Check Setup

<u>80% AM Expected Value Estimation:</u>
(From PC63.19 §I4.1.1)

(Eq I.3) **Calculation of AM Peak-to-Average Ratio (PAR)**

$$PAR_{dB} = 10\log(m+1)^2$$

Peak to Average Ratio of 80%AM signal (*m=0.8*) = 5.1 dB ≡ 1.8 (linear units).
Crest Factor = PAR = 1.8.
Modulation factor = $\sqrt{cf}$ = 1.34

$$\text{80\%AM Expected Value} \equiv \frac{U_{CW-t\arg et}}{mf} \equiv \frac{U_{CW-t\arg et}}{\sqrt{cf}}$$

# 8. MODULATION FACTOR

A calibration was made of the modulation response of the probe and its instrumentation chain. This calibration was performed with the field probe, attached to its instrumentation. The response of the probe system to a CW field at the frequency of interest is compared to its response to a modulated signal with equal peak amplitude to that of a CW signal. The field level of the test signals are ensured to be more than 10 dB above the ambient level and the noise floor of the instrumentation being used. The ratio of the CW reading to that taken with a modulated reading was applied to the DUT measurements.

**This was done using the following procedure:**

1. The probe was illuminated with a CW signal at the intended measurement frequency.
2. The probe was positioned at the field maxima over the dipole antenna (determined after an area scan over the dipole).
3. The reading of the probe measurement system of the CW signal at the maximum point was recorded.
4. Using a Spectrum Analyzer, the modulated signal adjusted with the same peak level of the CW signal was determined.
5. The probe measurement system reading was recorded with the modulated signal.
6. The ratio of the CW reading to modulated signal reading is the probe modulation factor (PMF) for the modulation and field probe combination.
7. Steps 1-6 were repeated at all frequency bands and for both E and H field probes.

The modulation factors obtained were applied to readings taken of the actual wireless device, in order to obtain an accurate peak field reading using the formula:

$$\text{Peak} = 20 \cdot \log(\text{Raw} \cdot \text{PMF})$$

This method correlates well with the modulation using the DUT in the alternative substitution method. See below for correlation of signal:

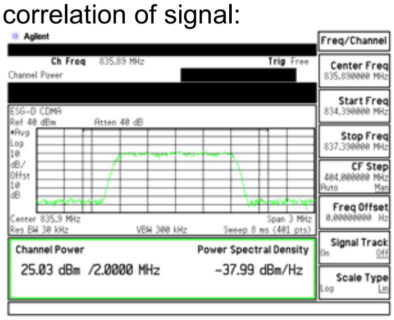



**Figure 23**
Signal Generator Modulated Signal

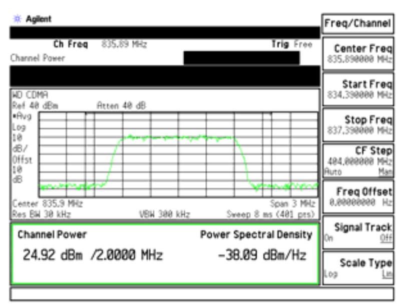



**Figure 24**
Wireless Device Modulated Signal

## Modulation Factors:

| f (MHz) | Peak Power (dBm) | Protocol | E-Field (V/m) | H-Field (A/m) | E-Field Modulation Factor | H-Field Modulation Factor |
|---|---|---|---|---|---|---|
| | | | | | | |
| 835 | 25.0 | AM | 204.5 | 0.5971 | 1.411 | 1.326 |
| 835 | 25.0 | CDMA | 311 | 0.9799 | 0.928 | 0.808 |
| 835 | 25.0 | CW | 288.6 | 0.7915 | | |
| | | | | | | |
| 1880 | 23.0 | AM | 129.2 | 0.5285 | 1.449 | 1.199 |
| 1880 | 23.0 | CDMA | 189 | 0.9041 | 0.990 | 0.701 |
| 1880 | 23.0 | CW | 187.2 | 0.6335 | | |

| f (MHz) | Protocol | E-Field (V/m) | H-Field (A/m) | E-Field Modulation Factor | H-Field Modulation Factor |
|---|---|---|---|---|---|
| | | | | | |
| 835 | CDMA / SO3 | 94.62 | 0.3175 | 2.270 | 2.147 |
| 835 | CW | 214.8 | 0.6818 | | |

**Figure 25**
Modulation Factors

## CW and Modulated Signal Zero-Span plots:

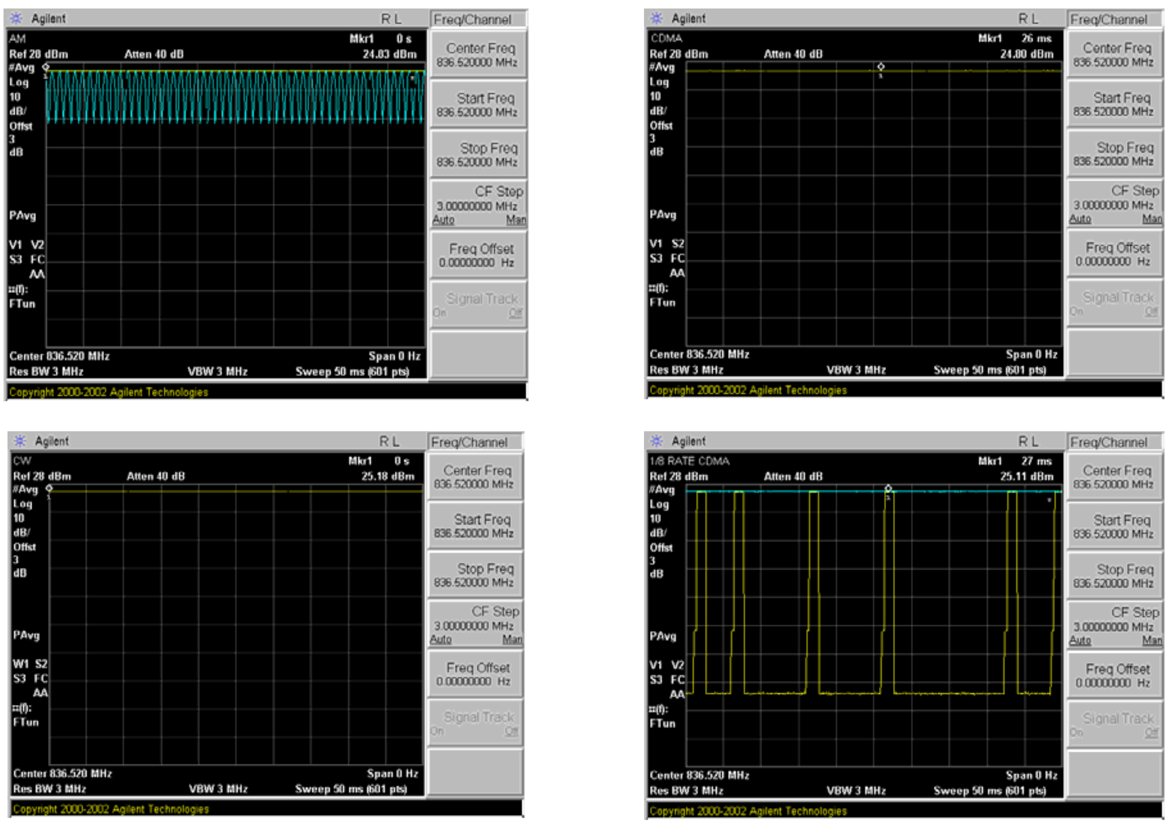



**Figure 26** Zero-Span Plots


 v02.11

# 9. OVERALL MEASUREMENT SUMMARY

| | |
|---|---|
| **FCC ID:** | QMNRM-124 |
| **Model:** | 2855i |
| **S/N:** | 215B9372 |

## I. E-FIELD EMISSIONS:

**Table 1**
**HAC Data Summary for E-field**

| Mode | Channel | Backlight | Talk Config | Antenna | Conducted Power at BS (dBm) | Time Avg. Field (V/m) | Peak Field (dBV/m) | FCC Limit (dBV/m) | FCC MARGIN (dB) | RESULT | Excl Blocks per 4.3.1.2.2 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **E-field Emissions** | | | | | | | | | | | |
| CDMA | 1013 | off | SO2 | In | 25.06 | 88.8 | 38.3 | **41.0** | **-2.68** | M3 | - |
| CDMA | 384 | off | SO2 | In | 24.88 | 89.3 | 38.4 | **41.0** | **-2.64** | M3 | - |
| CDMA | 777 | off | SO2 | In | 25.08 | 84.0 | 37.8 | **41.0** | **-3.16** | M3 | - |
| PCS | 25 | off | SO2 | In | 23.21 | 42.2 | 32.4 | **41.0** | **-8.58** | M4 | - |
| PCS | 600 | off | SO2 | In | 22.81 | 35.3 | 30.9 | **41.0** | **-10.13** | M4 | - |
| PCS | 1175 | off | SO2 | In | 22.71 | 41.3 | 32.2 | **41.0** | **-8.76** | M4 | - |
| | | | | | | | | | | | |
| CDMA | 1013 | off | SO2 | Out | 25.06 | 100.0 | 39.4 | **41.0** | **-1.65** | M3 | - |
| CDMA | 384 | off | SO2 | Out | 24.88 | 96.3 | 39.0 | **41.0** | **-1.97** | M3 | - |
| CDMA | 777 | off | SO2 | Out | 25.08 | 89.7 | 38.4 | **41.0** | **-2.60** | M3 | - |
| PCS | 25 | off | SO2 | Out | 23.21 | 33.5 | 30.4 | **41.0** | **-10.59** | M4 | - |
| PCS | 600 | off | SO2 | Out | 22.81 | 38.8 | 31.7 | **41.0** | **-9.30** | M4 | - |
| PCS | 1175 | off | SO2 | Out | 22.71 | 36.4 | 31.1 | **41.0** | **-9.87** | M4 | - |
| CDMA | 1013 | off | SO3 | Out | 25.06 | 29.8 | 36.6 | **41.0** | **-4.40** | M3 | - |
| CDMA | 1013 | on | SO2 | Out | 25.06 | 98.2 | 39.2 | **41.0** | **-1.81** | M3 | - |

**Figure 27**
Sample E-field Scan Overlay

Note: Worst-case measurement evaluated for worst-case 1/8 rate gating condition in RC1/SO3; Mute=Yes

| FCC ID: | QMNRM-124 |
|---|---|
| Model: | 2855i |
| S/N: | 215B9372 |

## II. H-FIELD EMISSIONS:

**Table 2**
**HAC Data Summary for H-field**

| Mode | Channel | Backlight | Talk Config | Antenna | Conducted Power at BS (dBm) | Time Avg. Field (A/m) | Peak Field (dBA/m) | FCC Limit (dBA/m) | FCC MARGIN (dB) | RESULT | Excl Blocks per 4.3.1.2.2 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **H-field Emissions** | | | | | | | | | | | |
| CDMA | 1013 | off | SO2 | In | 25.06 | 0.175 | -17.0 | **-9.4** | **-7.62** | M4 | - |
| CDMA | 384 | off | SO2 | In | 24.88 | 0.157 | -18.0 | **-9.4** | **-8.55** | M4 | - |
| CDMA | 777 | off | SO2 | In | 25.08 | 0.147 | -18.5 | **-9.4** | **-9.11** | M4 | - |
| PCS | 25 | off | SO2 | In | 23.21 | 0.100 | -23.1 | **-9.4** | **-13.69** | M4 | - |
| PCS | 600 | off | SO2 | In | 22.81 | 0.116 | -21.8 | **-9.4** | **-12.42** | M4 | - |
| PCS | 1175 | off | SO2 | In | 22.71 | 0.104 | -22.7 | **-9.4** | **-13.34** | M4 | - |
| CDMA | 1013 | off | SO3 | In | 25.06 | 0.063 | -17.4 | **-9.4** | **-8.03** | M4 | - |
| | | | | | | | | | | | |
| CDMA | 1013 | off | SO2 | Out | 25.06 | 0.150 | -18.3 | **-9.4** | **-8.92** | M4 | - |
| CDMA | 384 | off | SO2 | Out | 24.88 | 0.136 | -19.2 | **-9.4** | **-9.81** | M4 | - |
| CDMA | 777 | off | SO2 | Out | 25.08 | 0.125 | -19.9 | **-9.4** | **-10.52** | M4 | - |
| PCS | 25 | off | SO2 | Out | 23.21 | 0.086 | -24.4 | **-9.4** | **-15.01** | M4 | - |
| PCS | 600 | off | SO2 | Out | 22.81 | 0.105 | -22.6 | **-9.4** | **-13.24** | M4 | - |
| PCS | 1175 | off | SO2 | Out | 22.71 | 0.074 | -25.7 | **-9.4** | **-16.30** | M4 | - |

**Figure 28**
Sample H-field Scan Overlay

| | |
|---|---|
| **FCC ID:** | QMNRM-124 |
| **Model:** | 2855i |
| **S/N:** | 215B9372 |

## III. Worst-case Configuration Evaluation

**Table 3**
**Peak Reading 360° Probe Rotation at Azimuth axis**

| Mode | Channel | Backlight | Antenna | Conducted Power at BS (dBm) | Time Avg. Field (V/m) | Peak Field (dBV/m) | FCC Limit (dBV/m) | FCC MARGIN (dB) | RESULT |
|---|---|---|---|---|---|---|---|---|---|
| **Probe Rotation at Worst-Case** | | | | | | | | | |
| CDMA | 1013 | off | Out | 25.06 | 100.4 | 39.4 | **41.0** | **-1.62** | M3 |

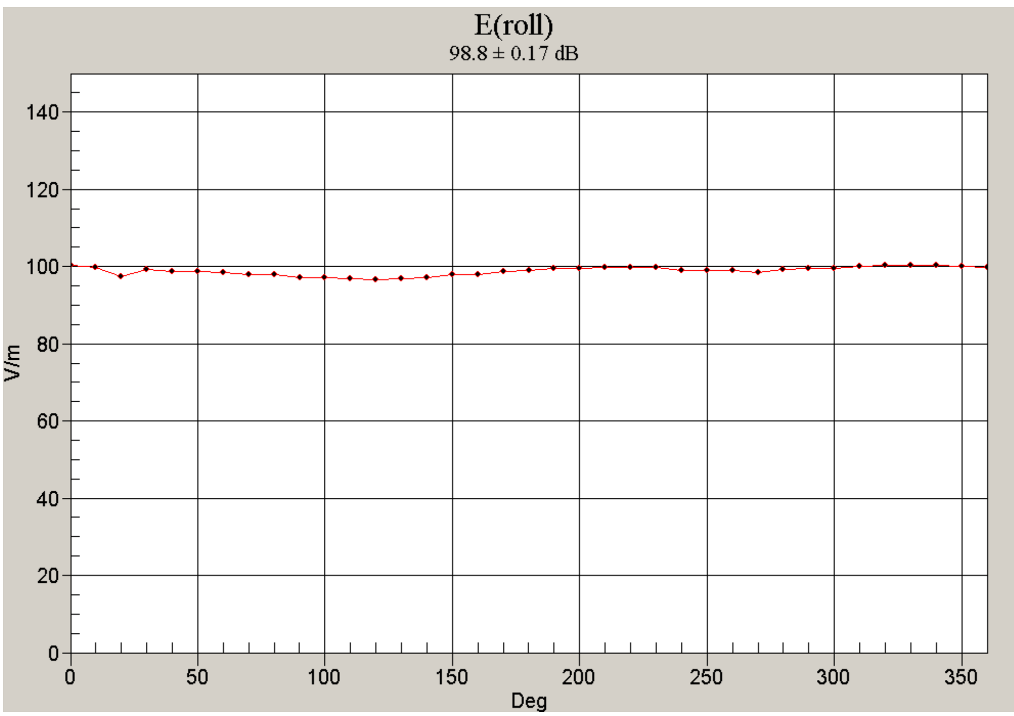



**Figure 29**
**Worst-Case Probe Rotation about Azimuth axis**

* Note: Location of probe rotation is shown in Figure 27 or Figure 28

# 10. EQUIPMENT LIST

| Manufacturer | Make / Equipment | Calibration Due | Asset No. |
|---|---|---|---|
| HP | 437B Power Meter | May 2006 | 3125U24437 |
| Amplifier Research | 5S1G4 (5W, 800MHz-4.2GHz) | January 2006 | 22322 |
| Gigatronics | 80701A (0.05-18GHz) Power Sensor | April 2006 | 1833460 |
| HP | 8482H (30mW-3W) Power Sensor | February 2006 | 2237A02084 |
| HP | 8594A Spectrum Analyzer | February 2006 | 3051A00187 |
| Gigatronics | 8657A Universal Power Meter | April 2006 | 1835256 |
| HP | 8753E (30kHz-6GHz) Network Analyzer | February 2006 | JP38020182 |
| Agilent | 8960 Base Station Simulator | January 2006 | PCT080 |
| Agilent | Base Station Simulator | May 2006 | 661 |
| Rohde & Schwarz | CMD80 Base Station Simulator | June 2006 | 830805/005 |
| Rohde & Schwarz | CMU200 Base Station Simulator | October 2006 | 650378 |
| Agilent | ESG-D Signal Generator | October 2006 | PCT800 |
| Optix | Fiber-Optic Line | N/A | |
| SPEAG | Freespace 1880 MHz Dipole | February 2007 | 1002 |
| SPEAG | Freespace 1900 MHz Dipole | February 2007 | 1002 |
| SPEAG | Freespace 2450 MHz Dipole | February 2007 | 1004 |
| SPEAG | Freespace H-field Probe | August 2006 | 6170 |
| SPEAG | Freespace E-field Probe | August 2006 | 2353 |
| Bruel & Kjaer | HATS System | December 2005 | 687 |
| Hosa | High Precision TRS Cable | N/A | |
| EMCO | Model 3115 (1-18GHz) Horn Antenna | October 2006 | 9203-2178 |
| EMCO | Model 3115 (1-18GHz) Horn Antenna | October 2006 | 9704-5182 |
| Rohde & Schwarz | NRVS Power Meter | June 2006 | |
| RF Lindgren Model 26-2/2-0 | Shielded Screen Room | N/A | 6710 (PCT270) |
| MicroCoax | (1.0-26.5GHz) Microwave Cables | N/A | N/A |
| HP | 8648D (9kHz-4GHz) Signal Generator | October 2006 | 3613A00315 |
| Rohde & Schwarz | (0.1-1000MHz) Signal Generator | September 2006 | 894215/012 |
| Ray Proof Model S81 | Shielded Semi-Anechoic Chamber | N/A | R2437 (PCT278) |
| Narda | 3020A (50-1000MHz) Bi-Directional Coax Coupler | January 2006 | |
| HP | 8901A Modulation Analyzer | January 2006 | 2432A03467 |
| HP | 8903B Audio Analyzer | January 2006 | 3011A09025 |

**Table 4**
Equipment List

*Calibration traceable to the National Institute of Standards and Technology (NIST).

# 11. MEASUREMENT UNCERTAINTY

| Wireless Communications Device Near-Field Measurement Uncertainty Estimation | | | | | | |
|---|---|---|---|---|---|---|
| Uncertainty Component | Data (dB) | Data Type | Prob. Dist. | Divisor | Unc. (dB) | Notes/Comments |
| **Measurement System** | | | | | | |
| RF System Reflections | 0.50 | Tolerance | R | 1.73 | 0.30 | * Refl. < -20 dB |
| RF Ambient Conditions | 0.20 | Tolerance | R | 1.73 | 0.12 | |
| Field Probe Conversion Factor | 0.42 | Tolerance | R | 1.73 | 0.25 | |
| Field Probe Isotropy | 0.11 | Tolerance | R | 1.73 | 0.06 | |
| Field Probe Frequency Response | 0.135 | Tolerance | R | 1.73 | 0.08 | |
| Field Probe Linearity | 0.025 | Tolerance | R | 1.73 | 0.01 | |
| Boundary Effects | 0.105 | Accuracy | R | 1.73 | 0.06 | |
| Sensor Displacement | 0.66 | Accuracy | R | 1.73 | 0.39 | * |
| Probe Positioning Accuracy | 0.20 | Accuracy | R | 1.73 | 0.12 | * |
| Probe Positioner | 0.050 | Accuracy | R | 1.73 | 0.03 | * |
| Extrapolation/Interpolation | 0.045 | Tolerance | R | 1.73 | 0.03 | * |
| System Detection Limit | 0.05 | Tolerance | R | 1.73 | 0.03 | * |
| Readout Electronics | 0.015 | Tolerance | N | 1.00 | 0.02 | * |
| Integration Time | 0.11 | Tolerance | R | 1.73 | 0.06 | * |
| Response Time | 0.033 | Tolerance | R | 1.73 | 0.02 | * |
| Phantom Thickness | 0.10 | Tolerance | R | 1.73 | 0.06 | * |
| **Test Sample Related** | | | | | | |
| Device Positioning Vertical | 0.4 | Tolerance | R | 1.73 | 0.24 | * |
| Device Positioning Lateral | 0.045 | Tolerance | N | 1 | 0.05 | * |
| Device Holder and Phantom | 0.1 | Tolerance | R | 1.73 | 0.06 | * |
| Power Drift | 0.21 | Tolerance | N | 1 | 0.21 | |
| *Combined Standard Uncertainty (k=1)* | | | | | 0.65 | 16.1% |
| ***Expanded Uncertainty (k=2) [95% confidence]*** | | | | | 1.30 | 32.3% |

**Table 5**
Uncertainty Estimation Table

Notes:
1. Test equipment are calibrated according to techniques outlined in NIS81, NIS3003 and NIST Tech Note 1297. All equipment have traceability according to NIST. Measurement Uncertainties are defined in further detail in NIS 81 and NIST Tech Note 1297 and UKAS M3003.
2. * Uncertainty specifications from Schmidt & Partner Engineering AG (not site specific)

Measurement uncertainty reflects the quality and accuracy of a measured result as compared to the true value. Such statements are generally required when stating results of measurements so that it is clear to the intended audience that the results may differ when reproduced by different facilities. Measurement results vary due to the measurement uncertainty of the instrumentation, measurement technique, and test engineer. Most uncertainties are calculated using the tolerances of the instrumentation used in the measurement, the measurement setup variability, and the technique used in performing the test. While not generally included, the variability of the equipment under test also figures into the overall measurement uncertainty. Another component of the overall uncertainty is based on the variability of repeated measurements (so-called Type A uncertainty). This may mean that the Hearing Aid immunity tests may have to be repeated by taking down the test setup and resetting it up so that there are a statistically significant number of repeat measurements to identify the measurement uncertainty. By combining the repeat measurement results with that of the instrumentation chain using the technique contained in NIS 81 and NIS 3003, the overall measurement uncertainty was estimated.

# 12. TEST DATA

See following Attached Pages for Test Data.

Date: 12/5/2005

PCTEST Hearing-Aid Compatability Facility

# DUT: HAC Dipole 835 MHz

Type: CD835V3
Serial: 1003

**Communication System: CW; Frequency: 835 MHz;**

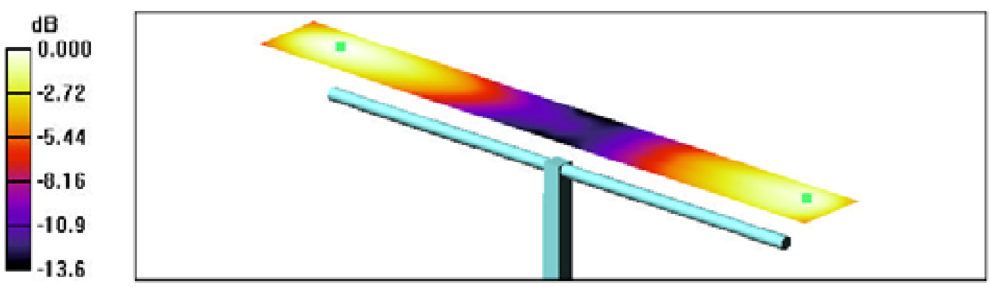
Measurement Standard: DASY4 (High Precision Assessment)

DASY4 Configuration:

- Probe: ER3DV6 - SN2353; Calibrated: 8/2/2005
- Sensor-Surface: 0mm (Fix Surface)
- Electronics: DAE4 Sn665; Calibrated: 8/8/2005
- Phantom: HAC; Type: SD HAC P01 BA;
- Measurement SW: DASY4, V4.6 Build 19;

## 835MHz, 100mW/20dBm/Hearing Aid Compatibility Test (101x901x1):

Measurement grid: dx=2mm, dy=2mm
Reference Value = 117.7 V/m; Power Drift = -0.042 dB
Average value of Total (interpolated) = 177.7 V/m




0 dB = 182.0V/m

Date: 12/5/2005

PCTEST Hearing-Aid Compatability Facility

# DUT: HAC Dipole 1900 MHz

Type: CD1880V3
Serial: 1002

**Communication System: CW; Frequency: 1880 MHz;**

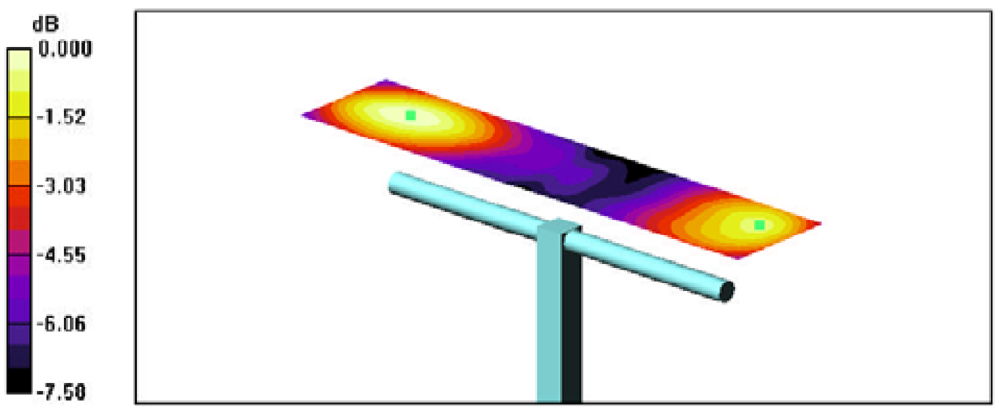
Measurement Standard: DASY4 (High Precision Assessment)

DASY4 Configuration:

- Probe: ER3DV6 - SN2353; Calibrated: 8/2/2005
- Sensor-Surface: 0mm (Fix Surface)
- Electronics: DAE4 Sn665; Calibrated: 8/8/2005
- Phantom: HAC; Type: SD HAC P01 BA;
- Measurement SW: DASY4, V4.6 Build 19;

## 1880MHz, 100mW/20dBm/Hearing Aid Compatibility Test (101x451x1):

Measurement grid: dx=2mm, dy=2mm
Reference Value = 144.0 V/m; Power Drift = -0.076 dB
Maximum value of Total (interpolated) = 149.8 V/m




0 dB = 149.8V/m

Date: 12/5/2005

PCTEST Hearing-Aid Compatability Facility

# DUT: HAC Dipole 835 MHz

Type: CD835V3
Serial: 1003

**Communication System: CW; Frequency: 835 MHz;**

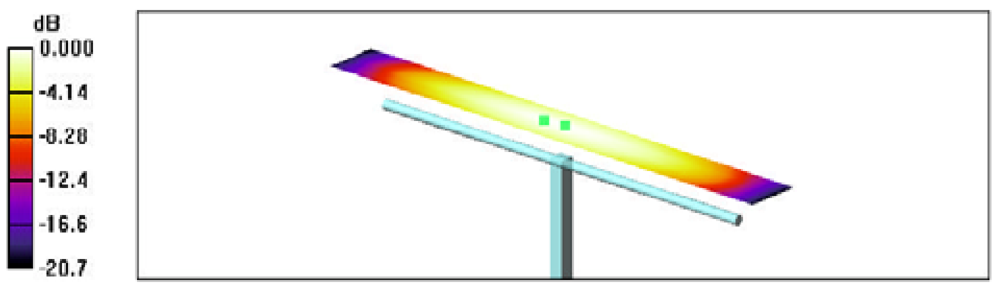
Measurement Standard: DASY4 (High Precision Assessment)

DASY4 Configuration:

- Probe: H3DV6 - SN6170; Calibrated: 8/8/2005
- Sensor-Surface: 0mm (Fix Surface)
- Electronics: DAE4 Sn665; Calibrated: 8/8/2005
- Phantom: HAC; Type: SD HAC P01 BA;
- Measurement SW: DASY4, V4.6 Build 19;

## 835MHz, 100mW/20dBm/Hearing Aid Compatibility Test (101x901x1):

Measurement grid: dx=2mm, dy=2mm
Reference Value = 0.534 A/m; Power Drift = -0.090 dB
Maximum value of Total (interpolated) = 0.499 A/m




0 dB = 0.499A/m

PCTEST Hearing-Aid Compatability Facility

# DUT: HAC Dipole 1900 MHz

Type: CD1880V3
Serial: 1002

**Communication System: CW; Frequency: 1880 MHz;**

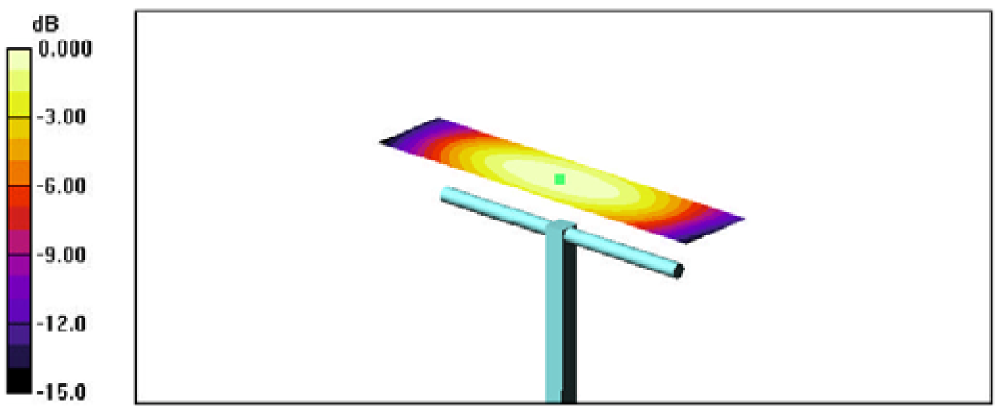
Measurement Standard: DASY4 (High Precision Assessment)

DASY4 Configuration:

- Probe: H3DV6 - SN6170; Calibrated: 8/8/2005
- Sensor-Surface: 0mm (Fix Surface)
- Electronics: DAE4 Sn665; Calibrated: 8/8/2005
- Phantom: HAC; Type: SD HAC P01 BA;
- Measurement SW: DASY4, V4.6 Build 19;

## 1880MHz, 100mW/20dBm/Hearing Aid Compatibility Test (101x451x1):

Measurement grid: dx=2mm, dy=2mm
Reference Value = 0.460 A/m; Power Drift = 0.056 dB
Maximum value of Total (interpolated) = 0.433 A/m




0 dB = 0.433A/m

Date: 11/28/2005

PCTEST wireless

PCTEST Hearing-Aid Compatability Facility

## DUT: 8255i

Type: Dual-Band Phone
Serial: 215B9372
*Backlight off*
*Duty Cycle: 1:1*

**Communication System: Cellular CDMA; Frequency: 824.7 MHz;**

Measurement Standard: DASY4 (High Precision Assessment)

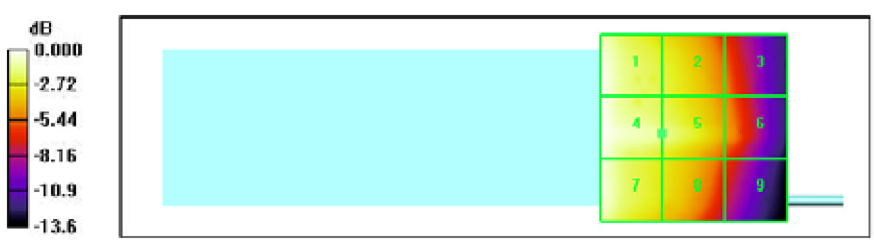
DASY4 Configuration:

- Probe: ER3DV6 - SN2353; Calibrated: 8/2/2005
- Sensor-Surface: (Fix Surface)
- Electronics: DAE4 Sn665; Calibrated: 8/8/2005
- Phantom: HAC; Type: SD HAC P01 BA;
- Measurement SW: DASY4, V4.6 Build 19;

**Ch.1013, Ant Out/Hearing Aid Compatibility Test (251x251x1):** Measurement grid: dx=2mm, dy=2mm
Maximum value of peak Total field = 96.8 V/m
Probe Modulation Factor = 0.968
Reference Value = 74.7 V/m; Power Drift = 0.103 dB
**Hearing Aid Near-Field Category: M3 (AWF 0 dB)**

Peak E-field in V/m

| | | |
|---|---|---|
| Grid 1 **96.1** | Grid 2 **74.8** | Grid 3 **54.5** |
| Grid 4 **96.8** | Grid 5 **82.2** | Grid 6 **58.3** |
| Grid 7 **93.6** | Grid 8 **71.1** | Grid 9 **49.1** |




0 dB = 96.8V/m

Date: 11/28/2005

PCTEST Hearing-Aid Compatability Facility

## DUT: 8255i

Type: Dual-Band Phone
Serial: 215B9372
*Backlight off*
*Duty Cycle: 1:1*

**Communication System: PCS CDMA; Frequency: 1851.25 MHz;**

Measurement Standard: DASY4 (High Precision Assessment)

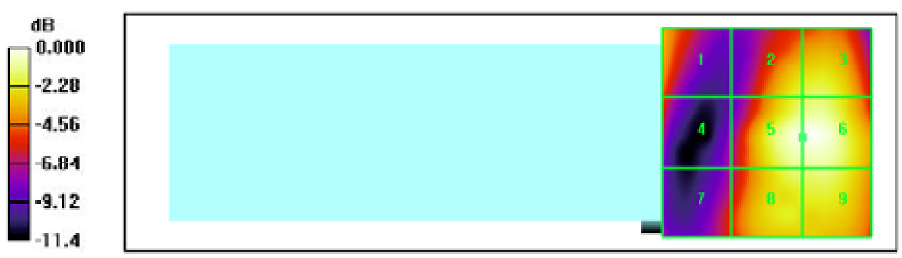
DASY4 Configuration:

- Probe: ER3DV6 - SN2353; Calibrated: 8/2/2005
- Sensor-Surface: (Fix Surface)
- Electronics: DAE4 Sn665; Calibrated: 8/8/2005
- Phantom: HAC; Type: SD HAC P01 BA;
- Measurement SW: DASY4, V4.6 Build 19;

**Ch.0025, Ant In/Hearing Aid Compatibility Test (251x251x1):** Measurement grid: dx=2mm, dy=2mm
Maximum value of peak Total field = 42.0 V/m
Probe Modulation Factor = 0.995
Reference Value = 29.2 V/m; Power Drift = -0.251 dB
**Hearing Aid Near-Field Category: M4 (AWF 0 dB)**

Peak E-field in V/m

| | | |
|---|---|---|
| Grid 1 29.2 | Grid 2 34.4 | Grid 3 35.3 |
| Grid 4 24.9 | Grid 5 41.4 | Grid 6 42.0 |
| Grid 7 22.3 | Grid 8 36.0 | Grid 9 36.5 |




0 dB = 42.0V/m

Date: 11/29/2005

PCTEST Hearing-Aid Compatability Facility

## DUT: 8255i

Type: Dual-Band Phone
Serial: 215B9372
*Backlight off*
*Duty Cycle: 1:1*

**Communication System: Cellular CDMA; Frequency: 824.7 MHz;**

Measurement Standard: DASY4 (High Precision Assessment)

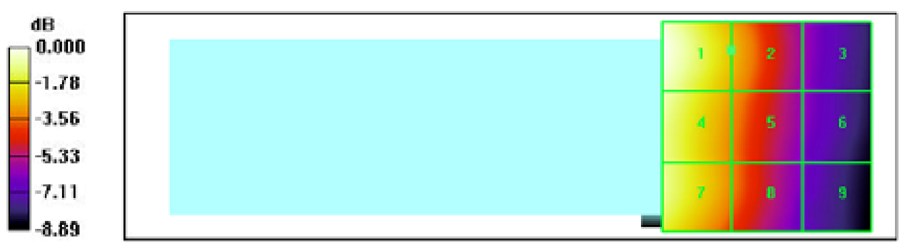
DASY4 Configuration:

- Probe: H3DV6 - SN6170; Calibrated: 8/8/2005
- Sensor-Surface: (Fix Surface)
- Electronics: DAE4 Sn665; Calibrated: 8/8/2005
- Phantom: HAC; Type: SD HAC P01 BA;
- Measurement SW: DASY4, V4.6 Build 19;

**Ch.1013, Ant In/Hearing Aid Compatibility Test (251x251x1):** Measurement grid: dx=2mm, dy=2mm
Maximum value of peak Total field = 0.150 A/m
Probe Modulation Factor = 0.858
Reference Value = 0.102 A/m; Power Drift = -0.007 dB
**Hearing Aid Near-Field Category: M4 (AWF 0 dB)**

Peak H-field in A/m

| | | |
|---|---|---|
| Grid 1 0.150 | Grid 2 0.113 | Grid 3 0.077 |
| Grid 4 0.142 | Grid 5 0.108 | Grid 6 0.075 |
| Grid 7 0.137 | Grid 8 0.103 | Grid 9 0.071 |




0 dB = 0.150A/m

Date: 11/29/2005

PCTEST Hearing-Aid Compatability Facility

## DUT: 8255i

Type: Dual-Band Phone
Serial: 215B9372
*Backlight off*
*Duty Cycle: 1:1*

**Communication System: PCS CDMA; Frequency: 1880 MHz;**

Measurement Standard: DASY4 (High Precision Assessment)

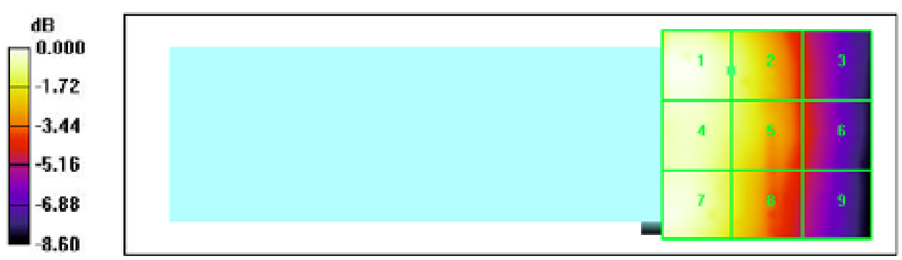
DASY4 Configuration:

- Probe: H3DV6 - SN6170; Calibrated: 8/8/2005
- Sensor-Surface: (Fix Surface)
- Electronics: DAE4 Sn665;
- Phantom: HAC; Type: SD HAC P01 BA;
- Measurement SW: DASY4, V4.6 Build 19;

**Ch.0600, Ant In/Hearing Aid Compatibility Test (251x251x1):** Measurement grid: dx=2mm, dy=2mm
Maximum value of peak Total field = 0.081 A/m
Probe Modulation Factor = 0.698
Reference Value = 0.083 A/m; Power Drift = 0.519 dB
**Hearing Aid Near-Field Category: M4 (AWF 0 dB)**

Peak H-field in A/m

| | | |
|---|---|---|
| Grid 1 **0.081** | Grid 2 **0.073** | Grid 3 **0.050** |
| Grid 4 **0.079** | Grid 5 **0.072** | Grid 6 **0.051** |
| Grid 7 **0.080** | Grid 8 **0.068** | Grid 9 **0.049** |




0 dB = 0.081A/m

# 13. CALIBRATION CERTIFICATES

The following pages include the probe calibration used to evaluate HAC for the DUT.

**Calibration Laboratory of**
Schmid & Partner
Engineering AG
**Zeughausstrasse 43, 8004 Zurich, Switzerland**

**S** Schweizerischer Kalibrierdienst
**C** Service suisse d'étalonnage
Servizio svizzero di taratura
**S** Swiss Calibration Service

Accredited by the Swiss Federal Office of Metrology and Accreditation
**The Swiss Accreditation Service is one of the signatories to the EA Multilateral Agreement for the recognition of calibration certificates**

**Accreditation No.: SCS 108**

Client **PC Test**

Certificate No: **ER3-2353_Aug05**

# CALIBRATION CERTIFICATE

| | |
|---|---|
| Object | ER3DV6 - SN:2353 |
| Calibration procedure(s) | QA CAL-02.v4<br>Calibration procedure for E-field probes optimized for close near field evaluations in air |
| Calibration date: | August 2, 2005 |
| Condition of the calibrated item | In Tolerance |

This calibration certificate documents the traceability to national standards, which realize the physical units of measurements (SI). The measurements and the uncertainties with confidence probability are given on the following pages and are part of the certificate.

All calibrations have been conducted in the closed laboratory facility: environment temperature (22 ± 3)°C and humidity < 70%.

Calibration Equipment used (M&TE critical for calibration)

| Primary Standards | ID # | Cal Date (Calibrated by, Certificate No.) | Scheduled Calibration |
|---|---|---|---|
| Power meter E4419B | GB41293874 | 3-May-05 (METAS, No. 251-00466) | May-06 |
| Power sensor E4412A | MY41495277 | 3-May-05 (METAS, No. 251-00466) | May-06 |
| Power sensor E4412A | MY41498087 | 3-May-05 (METAS, No. 251-00466) | May-06 |
| Reference 3 dB Attenuator | SN: S5054 (3c) | 10-Aug-04 (METAS, No. 251-00403) | Aug-05 |
| Reference 20 dB Attenuator | SN: S5086 (20b) | 3-May-05 (METAS, No. 251-00467) | May-06 |
| Reference 30 dB Attenuator | SN: S5129 (30b) | 10-Aug-04 (METAS, No. 251-00404) | Aug-05 |
| Reference Probe ER3DV6 | SN: 2328 | 6-Oct-04 (SPEAG, No. ER3-2328_Oct04) | Oct-05 |
| DAE4 | SN: 617 | 7-Jul-05 (SPEAG, No. DAE4-617_Jul05) | Jul-06 |

| Secondary Standards | ID # | Check Date (in house) | Scheduled Check |
|---|---|---|---|
| RF generator HP 8648C | US3642U01700 | 4-Aug-99 (SPEAG, in house check Dec-03) | In house check: Dec-05 |
| Network Analyzer HP 8753E | US37390585 | 18-Oct-01 (SPEAG, in house check Nov-04) | In house check: Nov 05 |

| | Name | Function | Signature |
|---|---|---|---|
| Calibrated by: | Katja Pokovic | Technical Manager | |
| Approved by: | Fin Bomholt | R&D Director | |

Issued: August 8, 2005

This calibration certificate shall not be reproduced except in full without written approval of the laboratory.

**Calibration Laboratory of**
Schmid & Partner
Engineering AG
**Zeughausstrasse 43, 8004 Zurich, Switzerland**

**S** **Schweizerischer Kalibrierdienst**
**C** **Service suisse d'étalonnage**
**S** **Servizio svizzero di taratura**
**Swiss Calibration Service**

Accredited by the Swiss Federal Office of Metrology and Accreditation
**The Swiss Accreditation Service is one of the signatories to the EA Multilateral Agreement for the recognition of calibration certificates**

**Accreditation No.: SCS 108**

**Glossary:**

| | |
|---|---|
| NORMx,y,z | sensitivity in free space |
| DCP | diode compression point |
| Polarization φ | φ rotation around probe axis |
| Polarization ϑ | ϑ rotation around an axis that is in the plane normal to probe axis (at measurement center), i.e., ϑ = 0 is normal to probe axis |
| Connector Angle | information used in DASY system to align probe sensor X to the robot coordinate system |

**Calibration is Performed According to the Following Standards:**

a) IEEE Std 1309-1996, " IEEE Standard for calibration of electromagnetic field sensors and probes, excluding antennas, from 9 kHz to 40 GHz", 1996.

**Methods Applied and Interpretation of Parameters:**

- *NORMx,y,z:* Assessed for E-field polarization ϑ = 0 for XY sensors and ϑ = 90 for Z sensor (f ≤ 900 MHz in TEM-cell; f > 1800 MHz: R22 waveguide).
- *NORM(f)x,y,z = NORMx,y,z * frequency_response* (see Frequency Response Chart).
- *DCPx,y,z:* DCP are numerical linearization parameters assessed based on the data of power sweep (no uncertainty required). DCP does not depend on frequency.
- *Spherical isotropy (3D deviation from isotropy)*: in a locally homogeneous field realized using an open waveguide setup.
- *Sensor Offset*: The sensor offset corresponds to the offset of virtual measurement center from the probe tip (on probe axis). No tolerance required.
- *Connector Angle*: The angle is assessed using the information gained by determining the *NORMx* (no uncertainty required).



# Probe ER3DV6

## SN:2353

Manufactured: March 8, 2005
Calibrated: August 2, 2005

Calibrated for DASY Systems

(Note: non-compatible with DASY2 system!)





# DASY - Parameters of Probe: ER3DV6 SN:2353

| Sensitivity in Free Space [μV/(V/m)$^2$] | | Diode Compression[A] | |
|---|---|---|---|
| NormX | **1.55** ± 10.1 % (k=2) | DCP X | **95** mV |
| NormY | **1.73** ± 10.1 % (k=2) | DCP Y | **95** mV |
| NormZ | **1.86** ± 10.1 % (k=2) | DCP Z | **96** mV |

## Frequency Correction

| | |
|---|---|
| X | **0.0** |
| Y | **0.0** |
| Z | **0.0** |

## Sensor Offset (Probe Tip to Sensor Center)

| | |
|---|---|
| X | **2.5** mm |
| Y | **2.5** mm |
| Z | **2.5** mm |

## Connector Angle **29** °

**The reported uncertainty of measurement is stated as the standard uncertainty of measurement multiplied by the coverage factor k=2, which for a normal distribution corresponds to a coverage probability of approximately 95%.**

[A] numerical linearization parameter: uncertainty not required

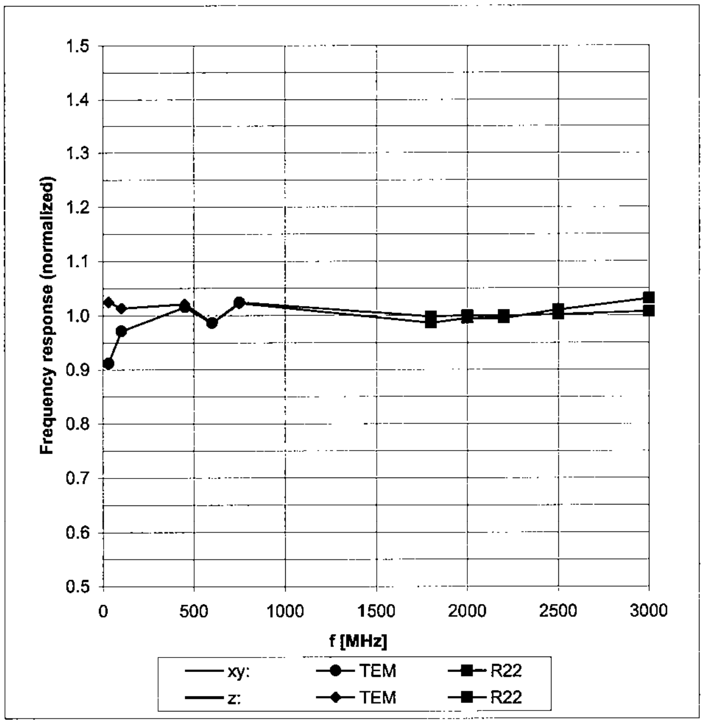




## Frequency Response of E-Field

**(TEM-Cell:ifi110 EXX, Waveguide R22)**



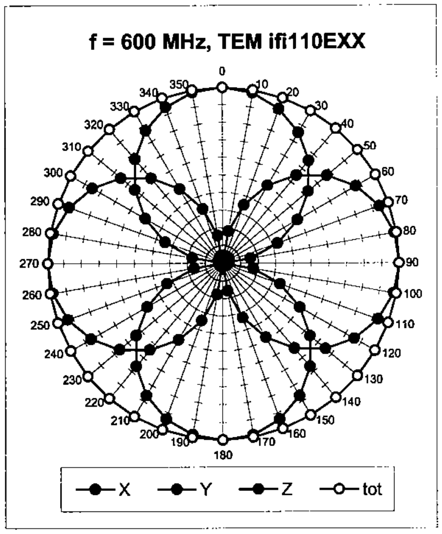

**Uncertainty of Frequency Response of E-field: ± 6.3% (k=2)**

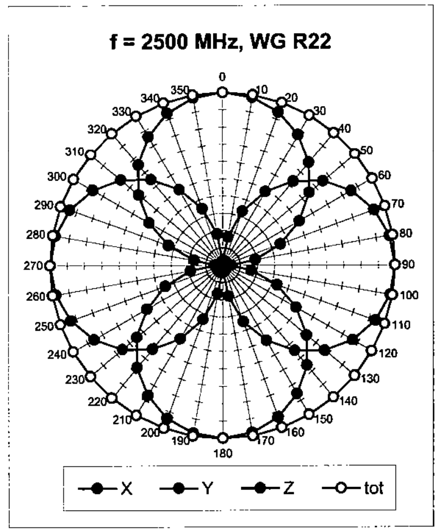




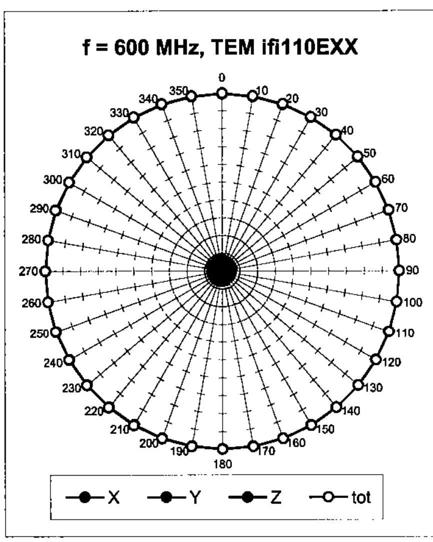
 v02.11

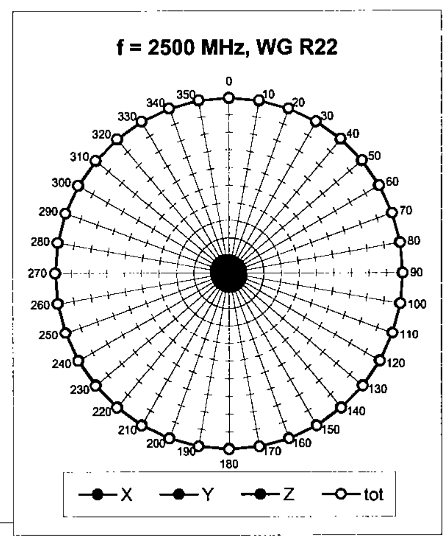
## Receiving Pattern (ϕ), $\vartheta = 0°$




## Receiving Pattern (ϕ), $\vartheta = 90°$





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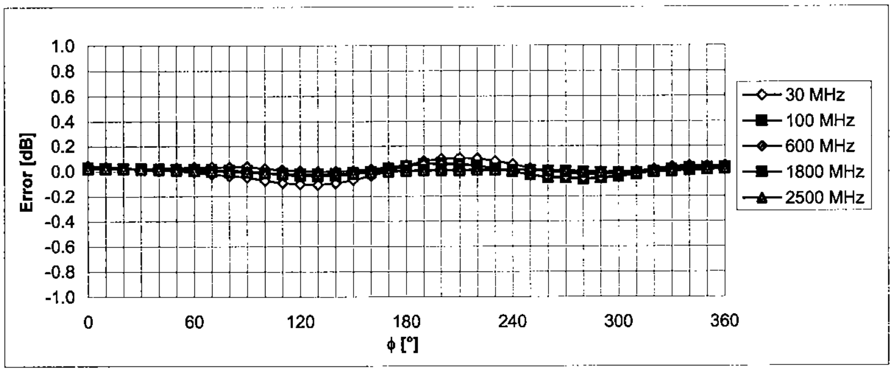
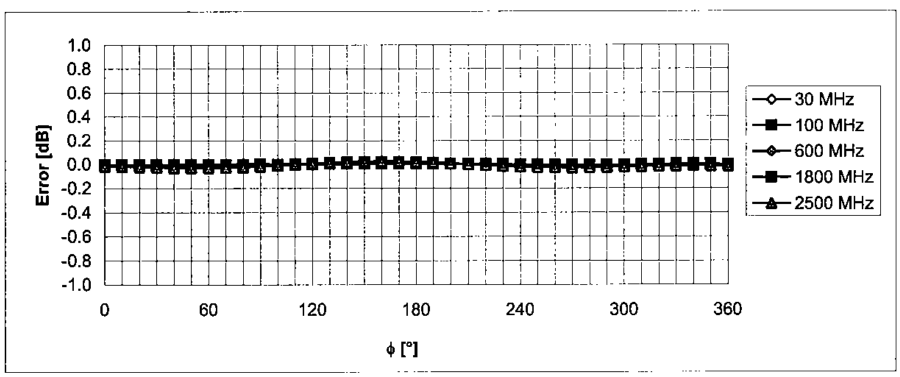
## Receiving Pattern (φ), ϑ = 0°




**Uncertainty of Axial Isotropy Assessment: ± 0.5% (k=2)**

## Receiving Pattern (φ), ϑ = 90°




**Uncertainty of Axial Isotropy Assessment: ± 0.5% (k=2)**

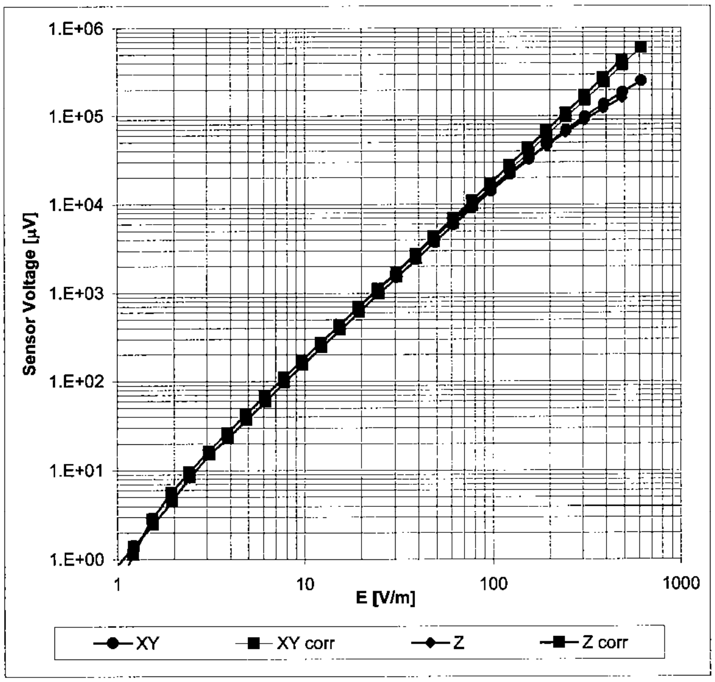


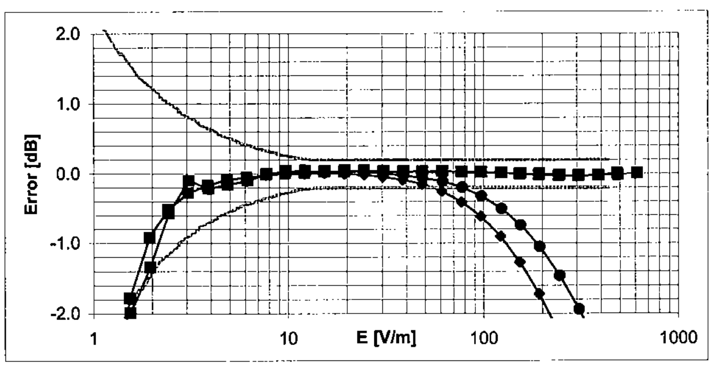


 v02.11

# Dynamic Range f(E-field)

**(Waveguide R22, f = 1800 MHz)**



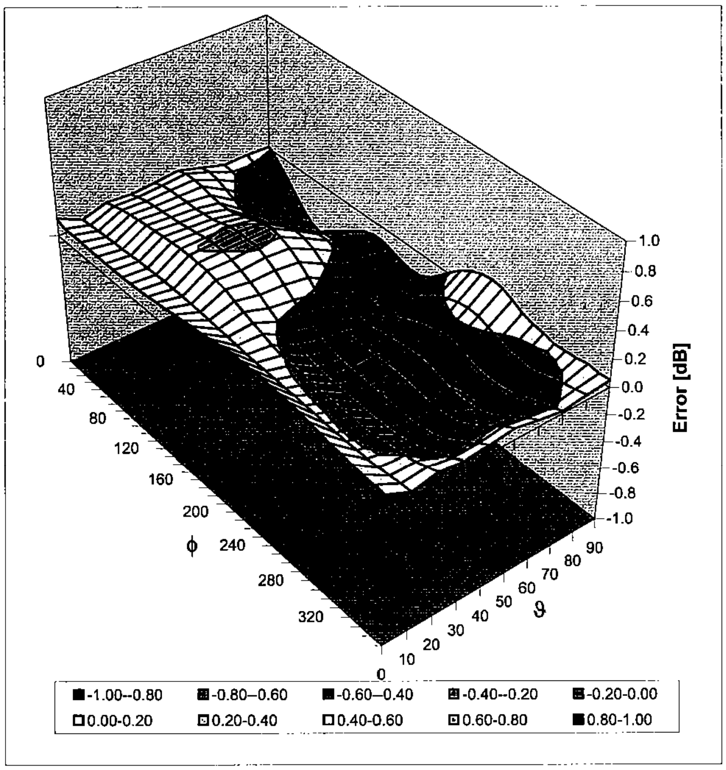

**Uncertainty of Linearity Assessment: ± 0.6% (k=2)**





 v02.11

# Deviation from Isotropy in Air
## Error ($\phi$, $\vartheta$), f = 900 MHz




**Uncertainty of Spherical Isotropy Assessment: ± 2.6% (k=2)**

**Calibration Laboratory of**
Schmid & Partner
Engineering AG
**Zeughausstrasse 43, 8004 Zurich, Switzerland**

**S** Schweizerischer Kalibrierdienst
**C** Service suisse d'étalonnage
Servizio svizzero di taratura
**S** Swiss Calibration Service

Accredited by the Swiss Federal Office of Metrology and Accreditation
**The Swiss Accreditation Service is one of the signatories to the EA Multilateral Agreement for the recognition of calibration certificates**

**Accreditation No.: SCS 108**

**Client** PC Test

**Certificate No: H3-6170_Aug05**

# CALIBRATION CERTIFICATE

| | |
|---|---|
| Object | H3DV6 - SN:6170 |
| Calibration procedure(s) | QA CAL-03.v4<br>Calibration procedure for H-field probes optimized for close near field evaluations in air |
| Calibration date: | August 8, 2005 |
| Condition of the calibrated item | In Tolerance |

This calibration certificate documents the traceability to national standards, which realize the physical units of measurements (SI).
The measurements and the uncertainties with confidence probability are given on the following pages and are part of the certificate.

All calibrations have been conducted in the closed laboratory facility: environment temperature (22 ± 3)°C and humidity < 70%.

Calibration Equipment used (M&TE critical for calibration)

| Primary Standards | ID # | Cal Date (Calibrated by, Certificate No.) | Scheduled Calibration |
|---|---|---|---|
| Power meter E4419B | GB41293874 | 3-May-05 (METAS, No. 251-00466) | May-06 |
| Power sensor E4412A | MY41495277 | 3-May-05 (METAS, No. 251-00466) | May-06 |
| Power sensor E4412A | MY41498087 | 3-May-05 (METAS, No. 251-00466) | May-06 |
| Reference 3 dB Attenuator | SN: S5054 (3c) | 10-Aug-04 (METAS, No. 251-00403) | Aug-05 |
| Reference 20 dB Attenuator | SN: S5086 (20b) | 3-May-05 (METAS, No. 251-00467) | May-06 |
| Reference 30 dB Attenuator | SN: S5129 (30b) | 10-Aug-04 (METAS, No. 251-00404) | Aug-05 |
| Reference Probe H3DV6 | SN: 6182 | 6-Oct-04 (SPEAG, No. H3-6182_Oct04) | Oct-05 |
| DAE4 | SN: 617 | 7-Jul-05 (SPEAG, No. DAE4-617_Jul05) | Jul-06 |

| Secondary Standards | ID # | Check Date (in house) | Scheduled Check |
|---|---|---|---|
| RF generator HP 8648C | US3642U01700 | 4-Aug-99 (SPEAG, in house check Dec-03) | In house check: Dec-05 |
| Network Analyzer HP 8753E | US37390585 | 18-Oct-01 (SPEAG, in house check Nov-04) | In house check: Nov 05 |

| | Name | Function | Signature |
|---|---|---|---|
| Calibrated by: | Katja Pokovic | Technical Manager | |
| Approved by: | Fin Bomholt | R&D Director | |

Issued: August 8, 2005

This calibration certificate shall not be reproduced except in full without written approval of the laboratory.

**Glossary:**

| | |
|---|---|
| NORMx,y,z | sensitivity in free space |
| DCP | diode compression point |
| Polarization φ | φ rotation around probe axis |
| Polarization ϑ | ϑ rotation around an axis that is in the plane normal to probe axis (at measurement center), i.e., ϑ = 0 is normal to probe axis |
| Connector Angle | information used in DASY system to align probe sensor X to the robot coordinate system |

**Calibration is Performed According to the Following Standards:**

a) IEEE Std 1309-1996, " IEEE Standard for calibration of electromagnetic field sensors and probes, excluding antennas, from 9 kHz to 40 GHz", 1996.

**Methods Applied and Interpretation of Parameters:**

- *X,Y,Z_a0a1a2:* Assessed for E-field polarization ϑ = 90 for XY sensors and ϑ = 0 for Z sensor (f ≤ 900 MHz in TEM-cell; f > 1800 MHz: R22 waveguide).
- *X,Y,Z(f)_a0a1a2= X,Y,Z_a0a1a2* frequency_response* (see Frequency Response Chart).
- *DCPx,y,z:* DCP are numerical linearization parameters assessed based on the data of power sweep (no uncertainty required). DCP does not depend on frequency.
- *Spherical isotropy (3D deviation from isotropy)*: in a locally homogeneous field realized using an open waveguide setup.
- *Sensor Offset*: The sensor offset corresponds to the offset of virtual measurement center from the probe tip (on probe axis). No tolerance required.
- *Connector Angle*: The angle is assessed using the information gained by determining the *X_a0a1a2* (no uncertainty required).





# Probe H3DV6

## SN:6170

Manufactured: May 19, 2005
Calibrated: August 8, 2005

Calibrated for DASY Systems

(Note: non-compatible with DASY2 system!)





# DASY - Parameters of Probe: H3DV6 SN:6170

## Sensitivity in Free Space [A/m / √(μV)]

| | a0 | a1 | a2 | |
|---|---|---|---|---|
| X | **2.502E-03** | **1.072E-4** | **-3.021E-6** | ± 5.1 % (k=2) |
| Y | **2.645E-03** | **2.739E-6** | **-2.811E-5** | ± 5.1 % (k=2) |
| Z | **2.960E-03** | **-6.594E-5** | **2.809E-5** | ± 5.1 % (k=2) |

## Diode Compression[1]

| | |
|---|---|
| DCP X | **85** mV |
| DCP Y | **85** mV |
| DCP Z | **86** mV |

## Sensor Offset (Probe Tip to Sensor Center)

| | |
|---|---|
| X | **3.0** mm |
| Y | **3.0** mm |
| Z | **3.0** mm |

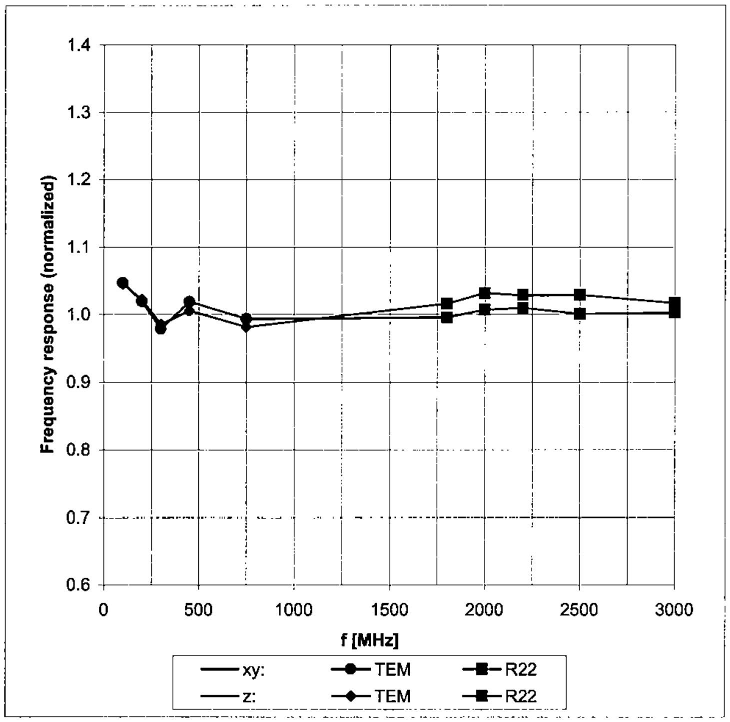
## Connector Angle **29** °

**The reported uncertainty of measurement is stated as the standard uncertainty of measurement multiplied by the coverage factor k=2, which for a normal distribution corresponds to a coverage probability of approximately 95%.**

[1] numerical linearization parameter: uncertainty not required

# Frequency Response of H-Field

**(TEM-Cell:ifi110, Waveguide R22)**




**Uncertainty of Frequency Response of E-field: ± 6.3% (k=2)**





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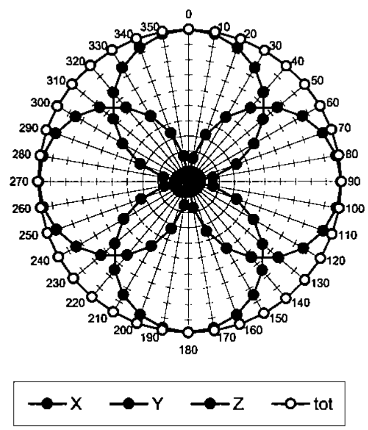
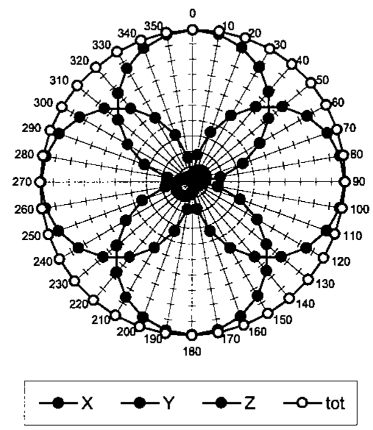
## Receiving Pattern (ϕ), ϑ = 90°

**f = 300 MHz, TEM ifi110EXX**

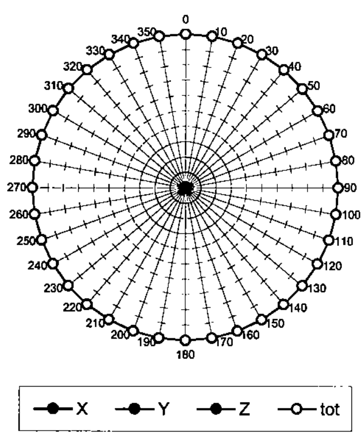



**f = 2500 MHz, WG R22**

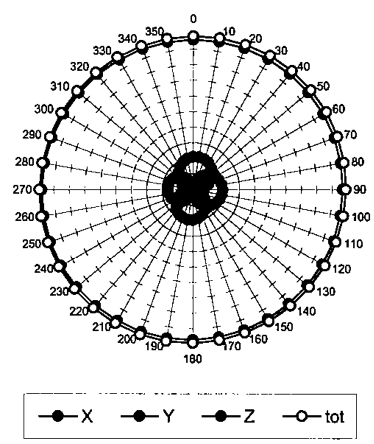



## Receiving Pattern (ϕ), ϑ = 0°

**f = 300 MHz, TEM ifi110EXX**




**f = 2500 MHz, WG R22**

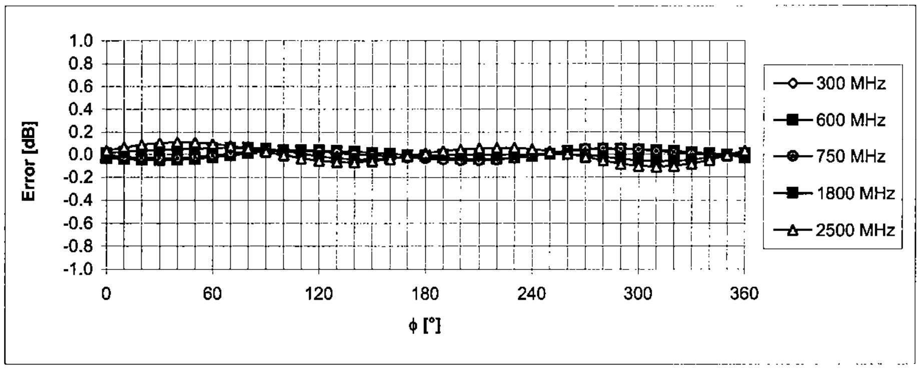






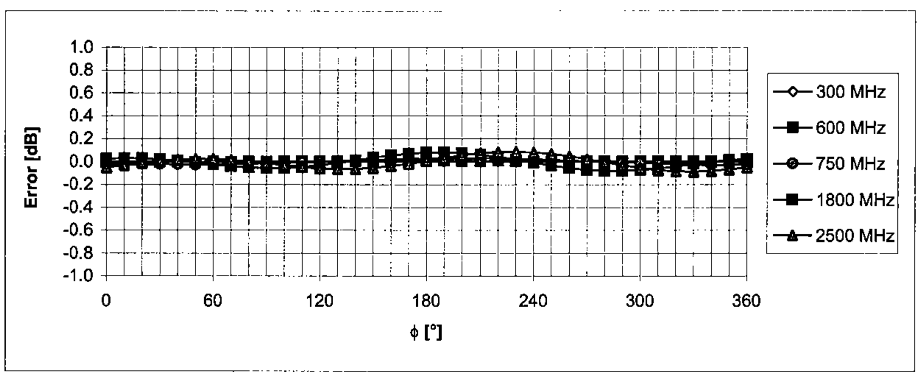

 

## Receiving Pattern (ϕ), ϑ = 90°




**Uncertainty of Axial Isotropy Assessment: ± 0.5% (k=2)**

## Receiving Pattern (ϕ), ϑ = 0°




**Uncertainty of Axial Isotropy Assessment: ± 0.5% (k=2)**

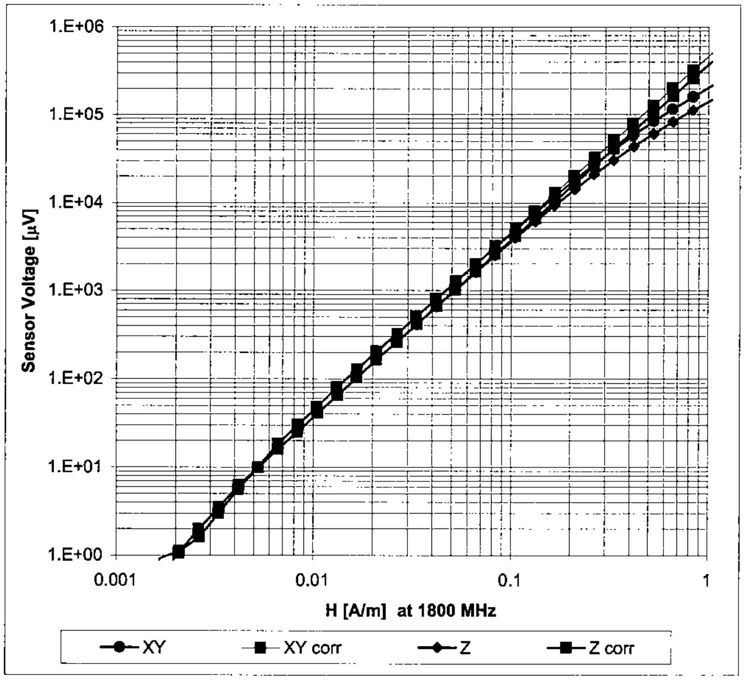


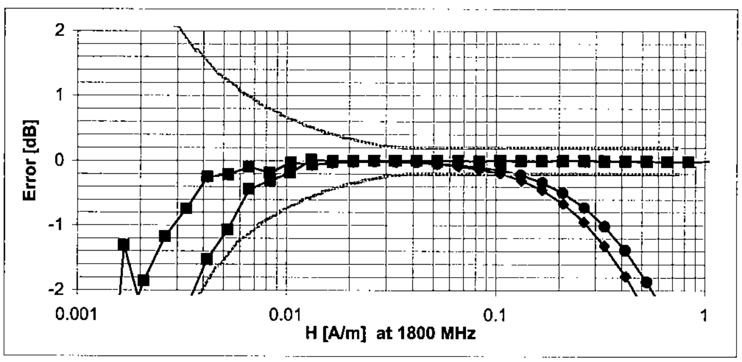


# Dynamic Range f(H-field)

**(Waveguide R22, f = 1800 MHz)**




**Uncertainty of Linearity Assessment: ± 0.6% (k=2)**





 v02.11

**Calibration Laboratory of**
Schmid & Partner
Engineering AG
**Zeughausstrasse 43, 8004 Zurich, Switzerland**

**Client** PC TEST

**Certificate No: CD1880V3-1002_Feb05**

# CALIBRATION CERTIFICATE

| | |
|---|---|
| Object | CD1880V3 - SN: 1002 |
| Calibration procedure(s) | QA CAL-20.v2<br>Calibration procedure for dipoles in air |
| Calibration date: | February, 23, 2005 |
| Condition of the calibrated item | In Tolerance |

This calibration certificate documents the traceability to national standards, which realize the physical units of measurements (SI).
All calibrations have been conducted in the closed laboratory facility: environment temperature (22 ± 3)°C and humidity < 70%.

Calibration Equipment used (M&TE critical for calibration)

| Primary Standards | ID # | Cal Date (Calibrated by, Certificate No.) | Scheduled Calibration |
|---|---|---|---|
| Power meter EPM E442 | GB37480704 | 12-Oct-04 (METAS, No. 251-00412) | Oct-05 |
| Power sensor HP 8481A | US37292783 | 12-Oct-04 (METAS, No. 251-00412) | Oct-05 |
| Reference 20 dB Attenuator | SN: 5086 (20g) | 10-Aug-04 (METAS, No 251-00402) | Aug-05 |
| Reference 10 dB Attenuator | SN: 5047.2 (10r) | 10-Aug-04 (METAS, No 251-00402) | Aug-05 |
| Reference Probe ER3DV6 | SN 2328 | 06-Oct-04 (SPEAG, No. ER3-2328_Oct04) | Oct-05 |
| DAE4 | SN 601 | 07-Jan-05 (SPEAG, No. DAE4-601_Jan05) | Jan-06 |

| Secondary Standards | ID # | Check Date (in house) | Scheduled Check |
|---|---|---|---|
| Power sensor HP 8481A | MY41092312 | 10-Aug-03 (SPEAG, in house check Jan-04) | In house check: Oct-05 |
| Power sensor HP 8481A | MY41093315 | 10-Aug-03 (SPEAG, in house check Jan-04) | In house check: Oct-05 |
| RF generator Agilent E8251A | US41140111 | 4-Aug-03 (Agilent) | In house check: Aug-05 |
| Network Analyzer HP 8753E | US37390585 S4206 | 18-Oct-01 (SPEAG, in house check Nov-04) | In house check: Nov-05 |
| Probe H3DV6 | SN: 6065 | 10-Oct-04 (SPEAG, No. H3-6065-Oct04) | Calibration, Oct-05 |

| | Name | Function | Signature |
|---|---|---|---|
| Calibrated by: | Mike Meili | Laboratory Technician | M Meili |
| Approved by: | Fin Bomholt | Technical Director | F. Bomholt |

Issued: February 27, 2005

This calibration certificate is issued as an intermediate solution until the specific calibration procedure is submitted and accepted in the frame of the accreditation of the Calibration Laboratory of Schmid & Partner Engineering AG (based on ISO/IEC 17025 International Standard)



**Calibration Laboratory of**
Schmid & Partner
Engineering AG
**Zeughausstrasse 43, 8004 Zurich, Switzerland**

**References**
[1] ANSI-PC63.19-2003 (Draft)
American National Standard for Methods of Measurement of Compatibility between Wireless Communications Devices and Hearing Aids.

**Methods Applied and Interpretation of Parameters:**

- *Coordinate System:* y-axis is in the direction of the dipole arms. z-axis is from the basis of the antenna (mounted on the table) towards its feed point between the two dipole arms. x-axis is normal to the other axes. In coincidence with standard [1], the measurement planes (probe sensor center) are selected to be at a distance of 10 mm above the the top edge of the dipole arms.
- *Measurement Conditions:* Further details are available from the hardcopies at the end of the certificate. All figures stated in the certificate are valid at the frequency indicated. The forward power to the dipole connector is set with a calibrated power meter connected and monitored with an auxiliary power meter connected to a directional coupler. While the dipole under test is connected, the forward power is adjusted to the same level.
- *Antenna Positioning:* The dipole is mounted on a HAC Test Arch phantom using the matching dipole positioner with the arms horizontal and the feeding cable coming from the floor. The measurements are performed in a shielded room with absorbers around the setup to reduce the reflections.
  It is verified before the mounting of the dipole under the Test Arch phantom, that its arms are perfectly in a line. It is installed on the HAC dipole positioner with its arms parallel below the dielectric reference wire and able to move elastically in vertical direction without changing its relative position to the top center of the Test Arch phantom. The vertical distance to the probe is adjusted after dipole mounting with a DASY4 Surface Check job. Before the measurement, the distance between phantom surface and probe tip is verified. The proper measurement distance is selected by choosing the matching section of the HAC Test Arch phantom with the proper device reference point (upper surface of the dipole) and the matching grid reference point (tip of the probe) considering the probe sensor offset. The vertical distance to the probe is essential for the accuracy.
- *Feed Point Impedance and Return Loss:* These parameters are measured using a HP 8753E Vector Network Analyzer. The impedance is specified at the SMA connector of the dipole. The influence of reflections was eliminating by applying the averaging function while moving the dipole in the air, at least 70cm away from any obstacles.
- *E- field distribution:* E field is measured in the x-y-plane with an isotropic ER3D-field probe with 100 mW forward power to the antenna feed point. In accordance with [1], the scan area is 20mm wide, its length exceeds the dipole arm length (180 or 90mm). The sensor center is 10 mm (in z) above the top of the dipole arms. Two 3D maxima are available near the end of the dipole arms. Assuming the dipole arms are perfectly in one line, the average of these two maxima (in subgrid 2 and subgrid 8) is determined to compensate for any non-parallelity to the measurement plane as well as the sensor displacement. The E-field value stated as calibration value represents the maximum of the interpolated 3D-E-field, 10mm above the dipole surface.
- *H-field distribution:* H-field is measured with an isotropic H-field probe with 100mW forward power to the antenna feed point, in the x-y-plane. The scan area and sensor distance is equivalent to the E-field scan. The maximum of the field is available at the center (subgrid 5) above the feed point. The H-field value stated as calibration value represents the maximum of the interpolated H-field, 10mm above the dipole surface at the feed point.



## 1 Measurement Conditions

DASY system configuration, as far as not given on page 1.

| | | |
|---|---|---|
| **DASY Version** | DASY4 | V4.5 B13 |
| **DASY PP Version** | SEMCAD | V1.8 B144 |
| **Phantom** | HAC Test Arch | SD HAC P01 BA, #1002 |
| **Distance Dipole Top - Probe Center** | 10 mm | |
| **Scan resolution** | dx, dy = 5 mm | area = 20 x 90 mm |
| **Frequency** | **1880 MHz** ± 1 MHz | |
| **Forward power at dipole connector** | 20.0 dBm = 100mW | |
| **Input power drift** | < 0.05 dB | |

## 2 Maximum Field values

| **H-field 10 mm above dipole surface** | condition | **interpolated maximum** |
|---|---|---|
| Maximum measured | 100 mW forward power | **0.450 A/m** |

Uncertainty for H-field measurement: 19.5% (k=2)

| **E-field 10 mm above dipole surface** | condition | **interpolated maximum** |
|---|---|---|
| Maximum measured above high end | 100 mW forward power | 146.0 V/m |
| Maximum measured above low end | 100 mW forward power | 145.6 V/m |
| Averaged maximum above arm | 100 mW forward power | **145.8 V/m** |

Uncertainty for E-field measurement: 21.7% (k=2)

## 3 Appendix

### 3.1 Antenna Parameters

| **Frequency** | **Return Loss** | **Impedance** |
|---|---|---|
| 1710 MHz | 23.4 dB | ( 55.2 + j6.1 ) Ohm |
| **1880 MHz** | **21.4 dB** | **( 53.9 + j7.4 ) Ohm** |
| 1900 MHz | 20.9 dB | ( 55.8 + j6.7 ) Ohm |
| 1950 MHz | 28.0 dB | ( 54.1 + j1.9 ) Ohm |
| 2000 MHz | 18.9 dB | ( 51.2 + j11.9 ) Ohm |

### 3.2 Antenna Design and Handling

The calibration dipole has a symmetric geometry with a built-in two stub matching network, which leads to the enhanced bandwidth.
The dipole is built of standard semirigid coaxial cable. The internal matching line is open ended. The antenna is therefore open for DC signals.
Do not apply force to dipole arms, as they are liable to bend. The soldered connections near the feedpoint may be damaged. After excessive mechanical stress or overheating, check the impedance characteristics to ensure that the internal matching network is not affected.

After long term use with 40W radiated power, only a slight warming of the dipole near the feedpoint can be measured.

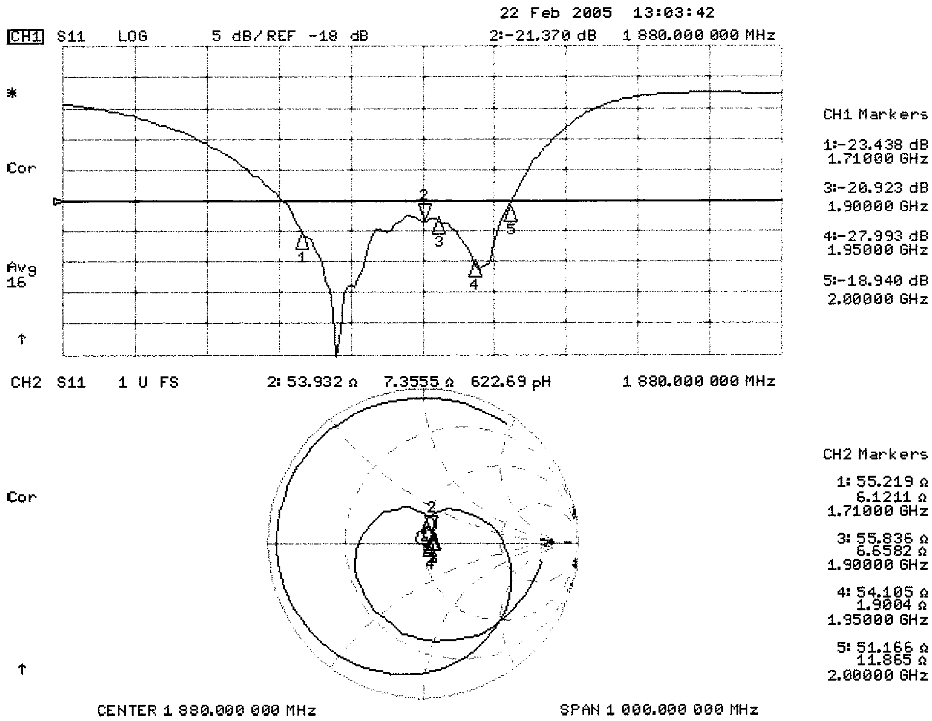




### 3.3 Measurement Sheets

#### 3.3.1 Return Loss and Smith Chart




#### 3.3.2 DASY4 H-field result

See page 5

#### 3.3.3 DASY4 E-Field result

See page 6





Test Laboratory: SPEAG, Zurich, Switzerland
File Name: H_CD1880_1002_050223.da4

**DUT: HAC Dipole 1880 MHz; Type: CD1880V3; Serial: 1002**
**Program Name: HAC H Dipole**

Communication System: CW; Frequency: 1880 MHz;Duty Cycle: 1:1
Medium parameters used: $\sigma = 0$; mho/m, $\varepsilon_r = 1$; $\rho = 1$ kg/m$^3$
Phantom section: H Dipole Section

DASY4 Configuration:
- Probe: H3DV6 - SN6065; ; Calibrated: 10.12.2004
- Sensor-Surface: (Fix Surface)
- Electronics: DAE4 Sn901; Calibrated: 29.06.2004
- Phantom: HAC Phantom; Type: SD HAC P01 BA;
- Measurement SW: DASY4, V4.5 Build 13; Postprocessing SW: SEMCAD, V1.8 Build 144

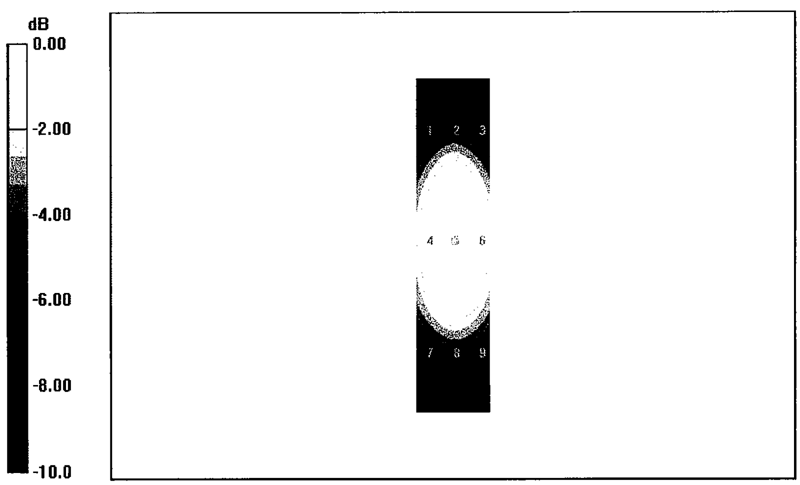
**H Scan 10mm above CD 1880 MHz/Hearing Aid Compatibility Test (41x181x1):** Measurement grid: dx=5mm, dy=5mm, dz=5.5555mm
Maximum value of Total field (slot averaged) = 0.450 A/m
**Hearing Aid Near-Field Category: M2 (AWF 0 dB)**

H in A/m (Time averaged)

| | | |
|---|---|---|
| Grid 1 **0.385** | Grid 2 **0.413** | Grid 3 **0.395** |
| Grid 4 **0.421** | Grid 5 **0.450** | Grid 6 **0.432** |
| Grid 7 **0.376** | Grid 8 **0.401** | Grid 9 **0.386** |

H in A/m (Slot averaged)

| | | |
|---|---|---|
| Grid 1 **0.385** | Grid 2 **0.413** | Grid 3 **0.395** |
| Grid 4 **0.421** | Grid 5 **0.450** | Grid 6 **0.432** |
| Grid 7 **0.376** | Grid 8 **0.401** | Grid 9 **0.386** |




0 dB = 0.450A/m



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Test Laboratory: SPEAG, Zurich, Switzerland
File Name: E_CD1880_1002_050223.da4

**DUT: HAC Dipole 1880 MHz; Type: CD1880V3; Serial: 1002**
**Program Name: HAC E Dipole**

Communication System: CW; Frequency: 1880 MHz;Duty Cycle: 1:1
Medium parameters used: $\sigma = 0$; mho/m, $\varepsilon_r = 1$; $\rho = 1000$ kg/m$^3$
Phantom section: E Dipole Section

DASY4 Configuration:
- Probe: ER3DV6 - SN2328; ConvF(1, 1, 1); Calibrated: 06.10.2004
- Sensor-Surface: (Fix Surface)
- Electronics: DAE4 Sn901; Calibrated: 29.06.2004
- Phantom: HAC Phantom; Type: SD HAC P01 BA;
- Measurement SW: DASY4, V4.5 Build 13; Postprocessing SW: SEMCAD, V1.8 Build 144

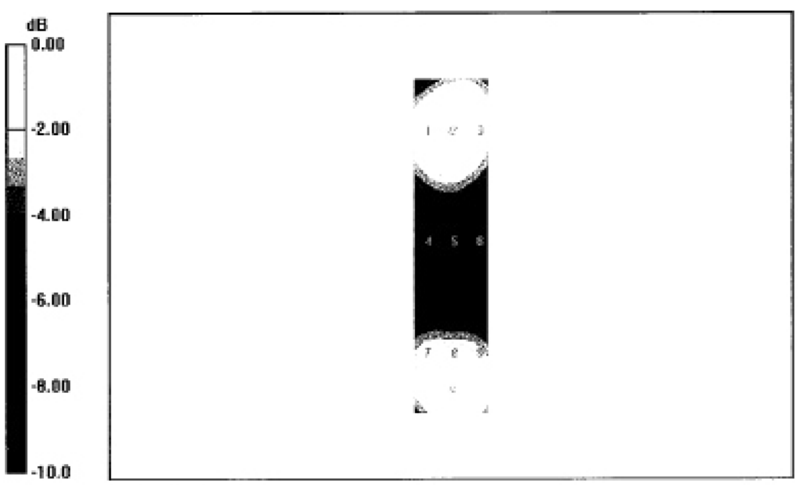
**E Scan 10mm above CD 1880 MHz/Hearing Aid Compatibility Test (41x181x1):** Measurement grid: dx=5mm, dy=5mm, dz=5.5555mm
Maximum value of Total field (slot averaged) = 146.0 V/m
**Hearing Aid Near-Field Category: M2 (AWF 0 dB)**

E in V/m (Time averaged)

| | | |
|---|---|---|
| Grid 1 **128.7** | Grid 2 **145.6** | Grid 3 **130.5** |
| Grid 4 **90.1** | Grid 5 **92.4** | Grid 6 **88.8** |
| Grid 7 **126.7** | Grid 8 **146.0** | Grid 9 **131.8** |

E in V/m (Slot averaged)

| | | |
|---|---|---|
| Grid 1 **128.7** | Grid 2 **145.6** | Grid 3 **130.5** |
| Grid 4 **90.1** | Grid 5 **92.4** | Grid 6 **88.8** |
| Grid 7 **126.7** | Grid 8 **146.0** | Grid 9 **131.8** |




0 dB = 146.0V/m



 v02.11

**Calibration Laboratory of**
Schmid & Partner
Engineering AG
**Zeughausstrasse 43, 8004 Zurich, Switzerland**

**Client** PC TEST **Certificate No: CD835V3-1003_Feb05**

# CALIBRATION CERTIFICATE

| | |
|---|---|
| Object | CD835V3 - SN: 1003 |
| Calibration procedure(s) | QA CAL-20.v2<br>Calibration procedure for dipoles in air |
| Calibration date: | February, 23, 2005 |
| Condition of the calibrated item | In Tolerance |

This calibration certificate documents the traceability to national standards, which realize the physical units of measurements (SI).
All calibrations have been conducted in the closed laboratory facility: environment temperature (22 ± 3)°C and humidity < 70%.

Calibration Equipment used (M&TE critical for calibration)

| Primary Standards | ID # | Cal Date (Calibrated by, Certificate No.) | Scheduled Calibration |
|---|---|---|---|
| Power meter EPM E442 | GB37480704 | 12-Oct-04 (METAS, No. 251-00412) | Oct-05 |
| Power sensor HP 8481A | US37292783 | 12-Oct-04 (METAS, No. 251-00412) | Oct-05 |
| Reference 20 dB Attenuator | SN: 5086 (20g) | 10-Aug-04 (METAS, No 251-00402) | Aug-05 |
| Reference 10 dB Attenuator | SN: 5047.2 (10r) | 10-Aug-04 (METAS, No 251-00402) | Aug-05 |
| Reference Probe ER3DV6 | SN 2328 | 06-Oct-04 (SPEAG, No. ER3-2328_Oct04) | Oct-05 |
| DAE4 | SN 601 | 07-Jan-05 (SPEAG, No. DAE4-601_Jan05) | Jan-06 |

| Secondary Standards | ID # | Check Date (in house) | Scheduled Check |
|---|---|---|---|
| Power sensor HP 8481A | MY41092312 | 10-Aug-03 (SPEAG, in house check Jan-04) | In house check: Oct-05 |
| Power sensor HP 8481A | MY41093315 | 10-Aug-03 (SPEAG, in house check Jan-04) | In house check: Oct-05 |
| RF generator Agilent E8251A | US41140111 | 4-Aug-03 (Agilent) | In house check: Aug-05 |
| Network Analyzer HP 8753E | US37390585 S4206 | 18-Oct-01 (SPEAG, in house check Nov-04) | In house check: Nov-05 |
| Probe H3DV6 | SN: 6065 | 10-Oct-04 (SPEAG, No. H3-6065-Oct04) | Calibration, Oct-05 |

| | Name | Function | Signature |
|---|---|---|---|
| Calibrated by: | Mike Meili | Laboratory Technician | M.Meili |
| Approved by: | Fin Bomholt | Technical Director | F. Bomholt |

Issued: February 27, 2005

This calibration certificate is issued as an intermediate solution until the specific calibration procedure is submitted and accepted in the frame of the accreditation of the Calibration Laboratory of Schmid & Partner Engineering AG (based on ISO/IEC 17025 International Standard)





 v02.11

**References**

[1] ANSI-PC63.19-2003 (Draft)
American National Standard for Methods of Measurement of Compatibility between Wireless Communications Devices and Hearing Aids.

**Methods Applied and Interpretation of Parameters:**

- *Coordinate System:* y-axis is in the direction of the dipole arms. z-axis is from the basis of the antenna (mounted on the table) towards its feed point between the two dipole arms. x-axis is normal to the other axes. In coincidence with standard [1], the measurement planes (probe sensor center) are selected to be at a distance of 10 mm above the the top edge of the dipole arms.
- *Measurement Conditions:* Further details are available from the hardcopies at the end of the certificate. All figures stated in the certificate are valid at the frequency indicated. The forward power to the dipole connector is set with a calibrated power meter connected and monitored with an auxiliary power meter connected to a directional coupler. While the dipole under test is connected, the forward power is adjusted to the same level.
- *Antenna Positioning:* The dipole is mounted on a HAC Test Arch phantom using the matching dipole positioner with the arms horizontal and the feeding cable coming from the floor. The measurements are performed in a shielded room with absorbers around the setup to reduce the reflections.
  It is verified before the mounting of the dipole under the Test Arch phantom, that its arms are perfectly in a line. It is installed on the HAC dipole positioner with its arms parallel below the dielectric reference wire and able to move elastically in vertical direction without changing its relative position to the top center of the Test Arch phantom. The vertical distance to the probe is adjusted after dipole mounting with a DASY4 Surface Check job. Before the measurement, the distance between phantom surface and probe tip is verified. The proper measurement distance is selected by choosing the matching section of the HAC Test Arch phantom with the proper device reference point (upper surface of the dipole) and the matching grid reference point (tip of the probe) considering the probe sensor offset. The vertical distance to the probe is essential for the accuracy.
- *Feed Point Impedance and Return Loss:* These parameters are measured using a HP 8753E Vector Network Analyzer. The impedance is specified at the SMA connector of the dipole. The influence of reflections was eliminating by applying the averaging function while moving the dipole in the air, at least 70cm away from any obstacles.
- *E- field distribution:* E field is measured in the x-y-plane with an isotropic ER3D-field probe with 100 mW forward power to the antenna feed point. In accordance with [1], the scan area is 20mm wide, its length exceeds the dipole arm length (180 or 90mm). The sensor center is 10 mm (in z) above the top of the dipole arms. Two 3D maxima are available near the end of the dipole arms. Assuming the dipole arms are perfectly in one line, the average of these two maxima (in subgrid 2 and subgrid 8) is determined to compensate for any non-parallelity to the measurement plane as well as the sensor displacement. The E-field value stated as calibration value represents the maximum of the interpolated 3D-E-field, 10mm above the dipole surface.
- *H-field distribution:* H-field is measured with an isotropic H-field probe with 100mW forward power to the antenna feed point, in the x-y-plane. The scan area and sensor distance is equivalent to the E-field scan. The maximum of the field is available at the center (subgrid 5) above the feed point. The H-field value stated as calibration value represents the maximum of the interpolated H-field, 10mm above the dipole surface at the feed point.

## 1 Measurement Conditions

DASY system configuration, as far as not given on page 1.

| | | |
|---|---|---|
| **DASY Version** | DASY4 | V4.5 B13 |
| **DASY PP Version** | SEMCAD | V1.8 B144 |
| **Phantom** | HAC Test Arch | SD HAC P01 BA, #1002 |
| **Distance Dipole Top - Probe Center** | 10 mm | |
| **Scan resolution** | dx, dy = 5 mm | area = 20 x 180 mm |
| **Frequency** | **835 MHz** ± 1 MHz | |
| **Forward power at dipole connector** | 20.0 dBm = 100mW | |
| **Input power drift** | < 0.05 dB | |

## 2 Maximum Field values

| **H-field 10 mm above dipole surface** | condition | **interpolated maximum** |
|---|---|---|
| Maximum measured | 100 mW forward power | **0.470 A/m** |

Uncertainty for H-field measurement: 19.5% (k=2)

| **E-field 10 mm above dipole surface** | condition | **interpolated maximum** |
|---|---|---|
| Maximum measured above high end | 100 mW forward power | 187.0 V/m |
| Maximum measured above low end | 100 mW forward power | 183.2 V/m |
| Averaged maximum above arm | 100 mW forward power | **185.1 V/m** |

Uncertainty for E-field measurement: 21.7% (k=2)

## 3 Appendix

### 3.1 Antenna Parameters

| **Frequency** | **Return Loss** | **Impedance** |
|---|---|---|
| 800 MHz | 16.6 dB | ( 40.5 - j9.6 ) Ohm |
| **835 MHz** | **25.2 dB** | **( 55.3 + j2.4 ) Ohm** |
| 900 MHz | 16.6 dB | ( 52.7 - j15.2 ) Ohm |
| 950 MHz | 25.1 dB | ( 50.9 + j5.5 ) Ohm |
| 960 MHz | 17.2 dB | ( 61.0 + j10.9 ) Ohm |

### 3.2 Antenna Design and Handling

The calibration dipole has a symmetric geometry with a built-in two stub matching network, which leads to the enhanced bandwidth.

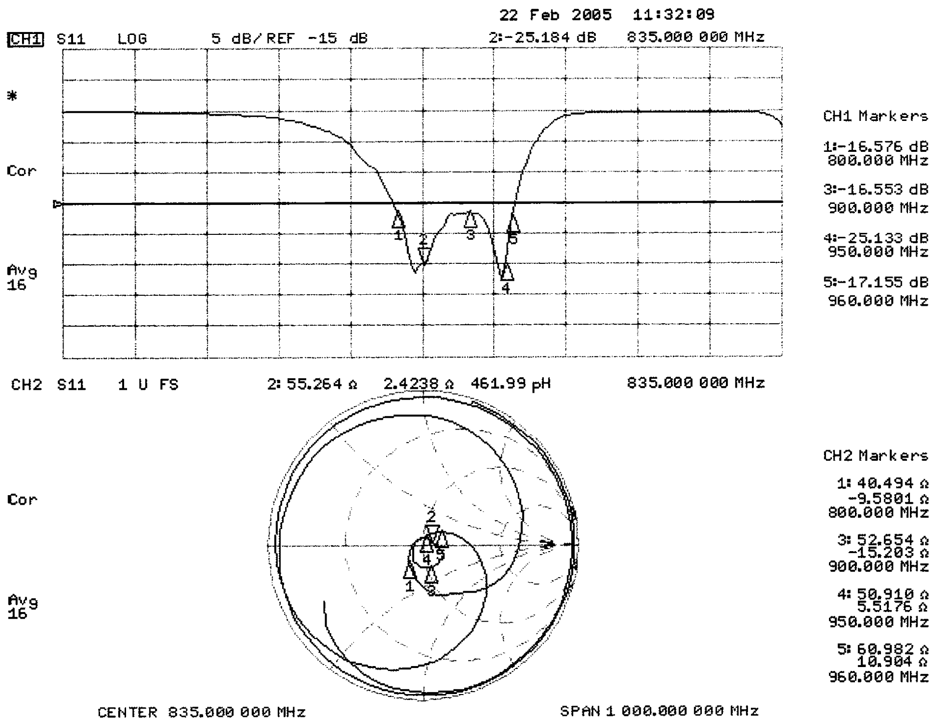
The dipole is built of standard semirigid coaxial cable. The internal matching line is open ended. The antenna is therefore open for DC signals.

Do not apply force to dipole arms, as they are liable to bend. The soldered connections near the feedpoint may be damaged. After excessive mechanical stress or overheating, check the impedance characteristics to ensure that the internal matching network is not affected.

After long term use with 40W radiated power, only a slight warming of the dipole near the feedpoint can be measured.

## 3.3 Measurement Sheets

### 3.3.1 Return Loss and Smith Chart




### 3.3.2 DASY4 H-field result

See page 5

### 3.3.3 DASY4 E-Field result

See page 6

Date/Time: 22.02.2005 17:22:00

Test Laboratory: SPEAG, Zurich, Switzerland
File Name: H_CD835_1003_050222.da4

**DUT: HAC-Dipole 835 MHz; Type: D835V3; Serial: 1003**
**Program Name: HAC H Dipole**

Communication System: CW; Frequency: 835 MHz;Duty Cycle: 1:1
Medium parameters used: $\sigma = 0$; mho/m, $\varepsilon_r = 1$; $\rho = 1$ kg/m$^3$
Phantom section: H Dipole Section

DASY4 Configuration:
- Probe: H3DV6 - SN6065; ; Calibrated: 10.12.2004
- Sensor-Surface: (Fix Surface)
- Electronics: DAE4 Sn901; Calibrated: 29.06.2004
- Phantom: HAC Phantom; Type: SD HAC P01 BA; Serial: 1002
- Measurement SW: DASY4, V4.5 Build 13; Postprocessing SW: SEMCAD, V1.8 Build 144

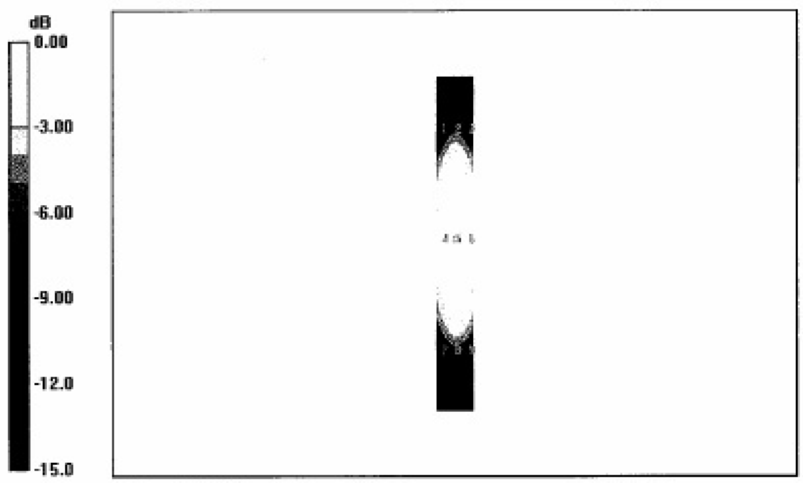
**H Scan 10mm above CD 835 MHz/Hearing Aid Compatibility Test (41x361x1):** Measurement grid: dx=5mm, dy=5mm, dz=5.5555mm
Maximum value of Total field (slot averaged) = 0.470 A/m
**Hearing Aid Near-Field Category: M2 (AWF 0 dB)**

H in A/m (Time averaged)

| | | |
|---|---|---|
| Grid 1 **0.365** | Grid 2 **0.397** | Grid 3 **0.380** |
| Grid 4 **0.408** | Grid 5 **0.470** | Grid 6 **0.425** |
| Grid 7 **0.350** | Grid 8 **0.380** | Grid 9 **0.368** |

H in A/m (Slot averaged)

| | | |
|---|---|---|
| Grid 1 **0.365** | Grid 2 **0.397** | Grid 3 **0.380** |
| Grid 4 **0.408** | Grid 5 **0.470** | Grid 6 **0.425** |
| Grid 7 **0.350** | Grid 8 **0.380** | Grid 9 **0.368** |




0 dB = 0.470 A/m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Date/Time: 23.02.2005 14:29:23

Test Laboratory: SPEAG, Zurich, Switzerland
File Name: E_CD835_1003_050223.da4

**DUT: HAC-Dipole 835 MHz; Type: D835V3; Serial: 1003**
**Program Name: HAC E Dipole**

Communication System: CW; Frequency: 835 MHz;Duty Cycle: 1:1
Medium parameters used: σ = 0; mho/m, $\varepsilon_r$ = 1; ρ = 1000 kg/m$^3$
Phantom section: E Dipole Section

DASY4 Configuration:
- Probe: ER3DV6 - SN2328; ConvF(1, 1, 1); Calibrated: 06.10.2004
- Sensor-Surface: (Fix Surface)
- Electronics: DAE4 Sn901; Calibrated: 29.06.2004
- Phantom: HAC Phantom; Type: SD HAC P01 BA; Serial: 1002
- Measurement SW: DASY4, V4.5 Build 13; Postprocessing SW: SEMCAD, V1.8 Build 144

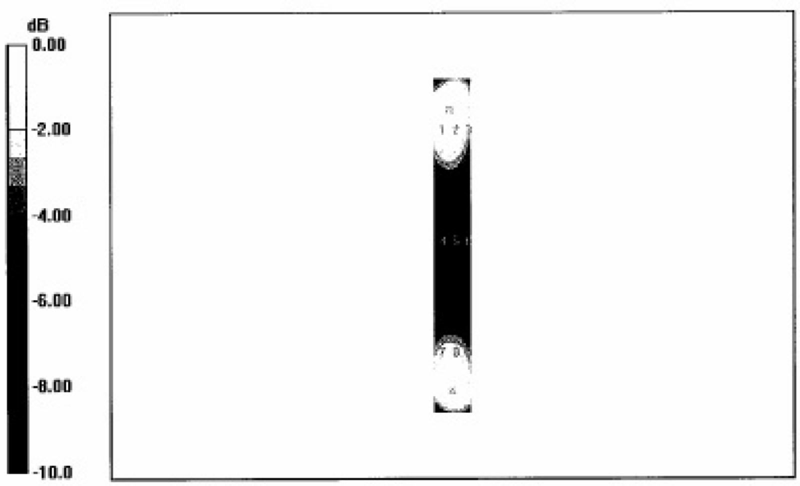
**E Scan 10mm above CD 835 MHz/Hearing Aid Compatibility Test (41x361x1):** Measurement grid: dx=5mm, dy=5mm, dz=5.5555mm
Maximum value of Total field (slot averaged) = 187.0 V/m
**Hearing Aid Near-Field Category: M2 (AWF 0 dB)**

E in V/m (Time averaged)

| | | |
|---|---|---|
| Grid 1 **156.0** | Grid 2 **187.0** | Grid 3 **150.1** |
| Grid 4 **83.6** | Grid 5 **84.8** | Grid 6 **80.4** |
| Grid 7 **148.0** | Grid 8 **183.2** | Grid 9 **149.5** |

E in V/m (Slot averaged)

| | | |
|---|---|---|
| Grid 1 **156.0** | Grid 2 **187.0** | Grid 3 **150.1** |
| Grid 4 **83.6** | Grid 5 **84.8** | Grid 6 **80.4** |
| Grid 7 **148.0** | Grid 8 **183.2** | Grid 9 **149.5** |




0 dB = 187.0 V/m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# 14. CONCLUSION

The measurements indicate that the wireless communications device complies with the HAC limits specified in accordance with the ANSI PC63.19 Standard and FCC WT Docket No. 01-309 RM-8658. Precise laboratory measures were taken to assure repeatability of the tests. The tested device complies with the requirements in respect to all parameters specific to the test. The test results and statements relate only to the item(s) tested.

Please note that the M-rating for this equipment only represents the field interference possible against a hypothetical and typical hearing aid. The measurement system and techniques presented in this evaluation are proposed in the ANSI standard as a means of best approximating wireless device compatibility with a hearing-aid. The literature is under continual re-construction.

# 15. REFERENCES


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